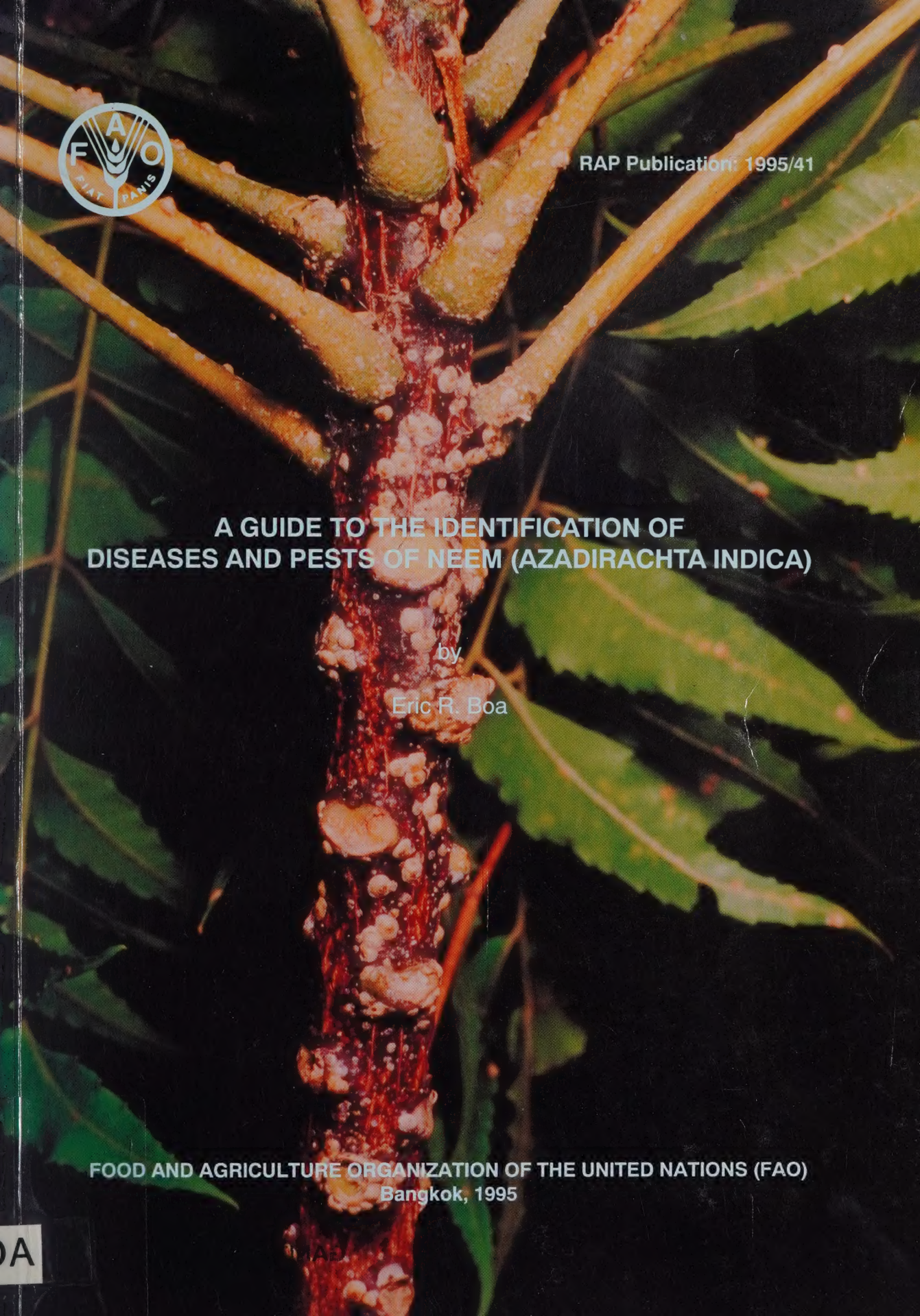

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A GUIDE TO THE IDENTIFICATION OF DISEASES AND PESTS OF NEEM (AZADIRACHTA INDICA)

by

Eric R. Boa

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO)
Bangkok, 1995

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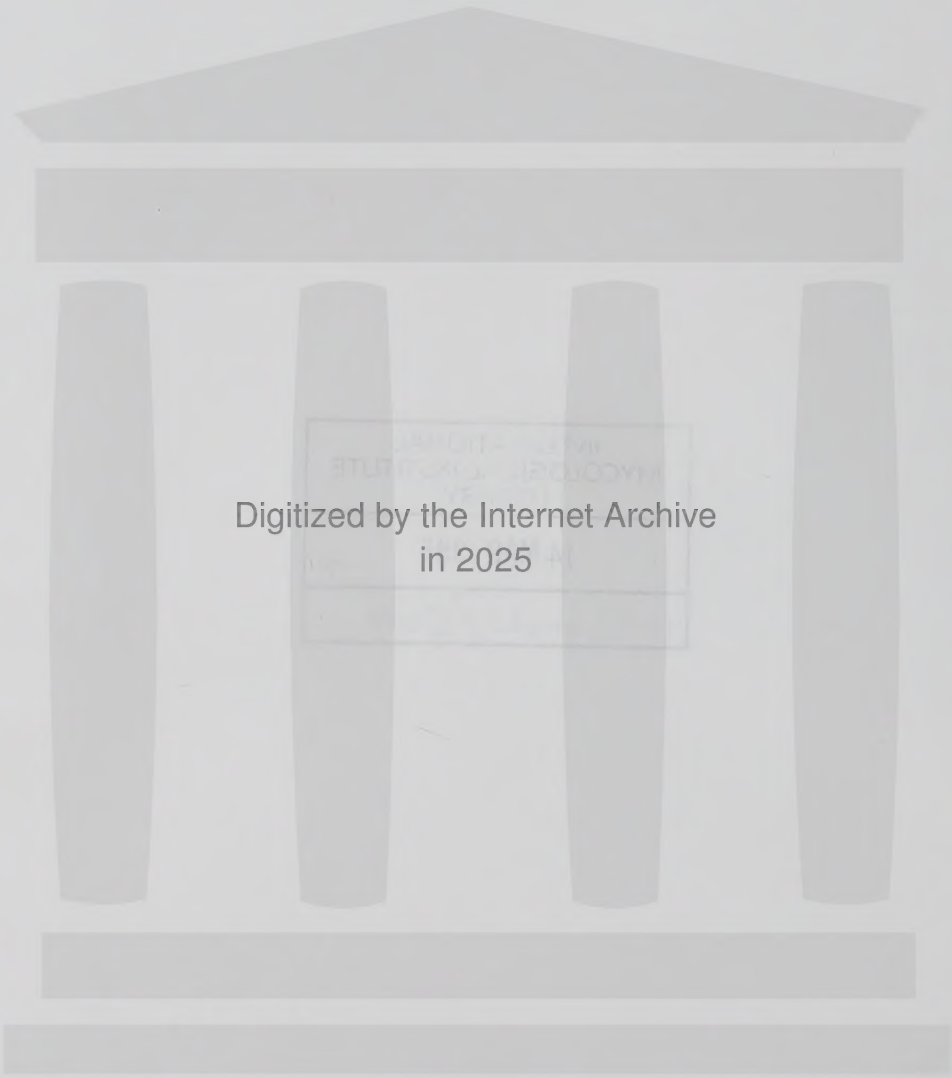
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A GUIDE TO THE IDENTIFICATION OF DISEASES AND PESTS OF NEEM (AZADIRACHTA INDICA)

by

Eric R. Boa

Collaborative Work Between

Forest Resources Division, Forestry Department
Rome, Italy

and

Regional Office for Asia and the Pacific (RAPA)
Bangkok, Thailand

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS (FAO)
Bangkok, 1995

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Those who study tree pests and diseases are few in number, particularly in tropical countries, and I would like to acknowledge a general and personal debt of gratitude to Ian Gibson, Chuck Hodges and Bill Ciesla, whose efforts have significantly contributed both to an increased knowledge of these problems and a need to pay them more attention.

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The designations and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

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Cover Photo: Infestation of the scale, *Aonidiella orientalis*, on neem, Maiduguri, Nigeria (Courtesy: William M. Ciesla)

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A GUIDE TO THE IDENTIFICATION OF DISEASES AND PESTS OF NEEM (*AZADIRACHTA INDICA*)[1]

1. INTRODUCTION

The neem tree, *Azadirachta indica*, has been referred to as a "cornucopia tree" or "miracle tree" because of the many goods and services that it has provided mankind for thousands of years. Neem grows vigorously under semi-arid as well as humid tropical conditions. Its spreading crown provides welcome shade from the tropical sun (Fig 1). It is an important source of fuelwood. Neem windbreaks afford protection to many agricultural crops from wind and its leaves and seeds have many beneficial and insecticidal properties. The insecticidal properties of neem are just beginning to be recognized on a large scale because the tree offers an environmentally friendly alternative to management of a number of crop and forest pests.

One would expect that a tree well known for its insecticidal properties to be relatively free from damaging insects and disease. Unfortunately, this is not the case. Neem is damaged by a wide range of insects, fungi, parasitic plants and other organisms. In addition, the tree is susceptible to a number of abiotic agents such as drought and fire. In recent years, two factors affecting the health of neem in the Sahel Region of West Africa have attracted international attention. These include the accidental introduction of the oriental scale of neem, *Aonidiella orientalis*, into this region during the 1970s and the occurrence of a widespread decline of neem, the causes of which are still not fully understood. A potential exists for other pest agents to cause widespread damage to this highly prized tree.

Purpose of this paper is to present an overview of the known pests and diseases of neem and is intended to serve as a guide to their identification. All types of pest organisms and damage affecting neem are included, from mammals to microscopic bacteria and mycoplasma-like organisms (MLOs). The largest group are the insect pests, followed by the fungi. The term "pest" is sometimes taken to include only insects but is used throughout this paper to refer to all categories of living organisms which affect neem trees. "Pest organism" is a less ambiguous term though slightly clumsy to use frequently in text. The term "disease" is defined as follows:

> *A condition where the normal functions of a plant are disturbed and harmed and may be caused by infectious agents or non-infectious factors (Holliday 1989).*

Parasitic plants (mistletoes) are also included in the scope of this paper, as are symptoms or conditions which are not associated with any known primary pest organism, the so-called abiotic diseases. These are also referred to as "disorders" and are usually associated with trees that have experienced undergone stress such as periods of drought, pollution or human interference. Included also are a group of disorders referred to as "declines or diebacks." These are complex disorders which are defined by Ciesla and Donaubauer (1994) as follows:

---

[1] Material contained in this paper was prepared by Dr Eric R. Boa, Plant Pathologist, International Mycological Institute, Engham, Surrey, UK.

Figure 1- In Kachako, Nigeria, a merchant sells dry peppers, onions and garlic under the comforting shade of a neem tree (Photo by W.M. Ciesla).

> *An episodic event characterized by premature loss of tree and stand vigour and health over a given period without obvious evidence of a single, clearly identifiable causal factor such as physical disturbance or attack by an aggressive disease or insect.*

Establishing the exact cause or causes of this group of disorders is difficult and requires detailed long term studies, and it is not surprising, given the nebulous nature of these diseases, that there is often controversy about their existence and how they have arisen.

A major condition affecting the health of neem in the Sahel, neem decline, has particular significance to this paper. Neem decline first came to international attention in Niger in 1990 (Ciesla, 1993a) and has provided the stimulus both for this paper and the organization of an international neem network. Concern about the appearance of an apparently "new" disease helped to gel widespread concern that not enough research attention and activity was being directed towards a tree species (see Read and French, 1993) that was being touted by many as a "tree to solve global problems" (National Research Council, 1992). There is a clear similarity here with events which followed the introduction of the leucaena psyllid, *Heteropsylla cubana*, into the Asia-Pacific Region and, more recently, into Africa (Napompeth 1994). Research projects were quickly put into place to consider how this major pest of a fast growing, multipurpose tree could be managed.

Both the dramatic appearance of neem decline and the rapid spread of leucaena psyllid demonstrate the important of pest management in forestry and agroforestry. Researchers and foresters must be aware of potential pest problems and regular monitoring and surveys

must be to carried out. Unfortunately, this rarely happens, and instead many problems are not detected at an early stage when the options for control are greater. There are few tree pest specialists available to assist with the often difficult task of identifying pests and diagnosing diseases on trees, and there is a dearth of suitable books, particularly those with photographs of pests and diseases, to assist the general forester in tree pest matters.

The paper aims to fill this gap for neem, and is directed at a broad readership interested in the neem tree. It is not concerned with the use of neem compounds in many of their potential applications. But it is also hoped that the publication of this paper will help to assemble comprehensive information about our present knowledge of neem pests and diseases and stimulate others to consider general pest management issues in relation to neem. The need for this improved knowledge and awareness is clear as the neem tree is widely promoted around the world for its many desirable attributes and properties.

There is another reason for paying attention to pests and diseases. Their status is liable to change should the environmental conditions under which they are found change. There was no indication in 1919 that *Aonidiella orientalis* was a major pest of neem following a report by Glover (1933). Yet, in 1987, the same insect was causing serious damage to neem in Cameroon and Nigeria (Akanbi et al 1990). The scale has since spread and is now widespread in northern Nigeria. There are many other scales on neem which are not considered at present to be serious pests. Scale attack by *Megapulvinaria maxima* was recognised as a significant pest early this century in India, yet there have been few and irregular reports of its occurrence since this early date. The reasons for this are not clear. It could be that there has been no noteworthy outbreak but it could also mean that significant outbreaks have not been reported. Vigilance is required at all times to ensure that early and prompt action is taken to control pests and diseases.

Further information on neem pests and diseases can be obtained from the references given in the text. However, most of these accounts are brief and do not contain significantly more detail than that provided here. Where further practical assistance is sought, for example in confirming the cause of a particular disease, you are recommended to get in touch with relevant pest specialists. Tree pest scientists are employed at major forest research institutes based in several tropical countries (e.g. Kerala and Dehra Dun in India and in Kenya, Malaysia and Nigeria) and these national institutes or related bodies should be the initial point of contact for practical enquiries. Where such advice is not available, or further specialist assistance is required (for example in identifying pest organisms), there are several international bodies which can be contacted. These include FAO in Rome or the CAB International Institute of Entomology (IIE) and International Mycological Institute (IMI) in the UK.

The neem tree, which is familiar to many because of its pesticidal properties, has a perhaps surprisingly large number of pest organisms which attack it, even if relatively few of these are known to cause with serious damage. This suggests a different line of research to that pursued in countless studies on pest management using neem compounds. Insects which feed on neem are obviously able to tolerate some if not all of the pesticidal compounds produced by the tree and an investigation of this tolerance or resistance might offer some new insights into the mode of action and practical application of neem compounds in biological control programmes.

2. THE NEEM TREE IN FORESTRY AND AGROFORESTRY

Most of the information provided below on the characteristics and role of the neem tree in forestry and agroforestry is included in a recent book on neem published by the National Research Council (1992). Another useful general account of the tree has been written by Tewari (1992). An account of current research activities on all aspects of the tree is provided in Read and French (1993).

The tree is originally a native of the Indian sub-continent and adjacent countries though the exact location of natural populations has been confused by the frequent movement of plant material. It has been widely planted throughout mostly tropical regions and it also occurs in sub-tropical regions where minimum temperatures do not exceed about 4° C. Neem is not cold tolerant.

The tree has a number of extremely valuable properties. It is fast growing and can survive in harsh semi-arid conditions where soils are poor and the rainfall exceeds 400 - 500 mm annually. It produces a good timber which is used in house construction and agricultural implements (Bostock Wood 1992). The tree coppices and pollards well and has a spreading crown that provides invaluable shade in often harsh climates. The foliage is used as a mulch for annual crops and neem leaves are eaten in Thailand. However, the tree is perhaps best known, at least in the North, for the varied properties of a cocktail of compounds which are most concentrated in the seeds. These compounds have been used in biological control and against various human diseases. There has been considerable research interest in these compounds (e.g. Schmutterer and Ascher 1987) and much excitement about their commercial applications.

In India, neem is valued both for the characteristics of the tree and the properties of neem compounds which have long been known by local people. But local appreciation of the tree in most if not all other countries where it has been introduced is largely derived from the tree as either a forestry or agroforestry species. This is true in West Africa where, despite the widespread planting of the tree, the use of neem compounds is very limited. In Sahelian Niger and Nigeria, neem has gained an unparalleled reputation amongst local people which accounts for its dominance in and around villages and towns (Fig 2). It has also been widely adopted by foresters, who have used it to establish thousands of kilometres of shelterbelts throughout the same region. These shelterbelts are designed to reduce the erosion of topsoil and protect agricultural crops planted between the shelterbelts. There are usually up to four rows of trees in a shelterbelt which are planted about 100 m apart.

Within India neem occurs both as individual trees in rural areas, frequently protected by local people, and as a planted roadside tree in urban conurbations. Woodlots and plantations have also been established though the scale of these does not suggest that neem is a major forestry species in India. In Nigeria, however, neem does have an important forestry role. In addition to shelterbelts, where neem is the dominant species, plantations have also been established. The scale of these plantations is relatively small compared to the neem populations in shelterbelts. Individual plantations in Sokoto and Jigawa states, for example, are rarely more than about 20 - 30 hectares.

Neem occurs in a similar pattern in Niger, Cameroon and Chad, where there is a mix of rural, urban and roadside populations. Shelterbelts also occur in Niger but plantations are more accurately described as woodlots, rarely exceeding 10 ha. The tree is also important

Figure 2 - Neems in a small village near Dogondoutchi, Niger. Neem is often the dominant tree in small villages across most of Sahelian West Africa (Photo by W.M. Ciesla)

Figure 3 - Neem was introduced into the Sudan during the 1920s. In these scene, large spreading neems shade a small village along the Blue Nile River (Photo by W.M. Ciesla).

in several other West African countries, particularly the drier regions. The tree was first introduced to Ghana in the 1920s and also about the same time to Sudan (Fig 3). There have been major planting programmes in other countries in the Caribbean and Central America. For example, about 400 000 neem seedlings were planted in Haiti in the early 1980s (Schmutterer and Ascher 1987). Similar though smaller programmes have taken place in Nicaragua. Neem has also been widely planted in tropical regions of South America and occurs throughout southeast Asia.

3. ORGANISATION AND SOURCES OF INFORMATION

3.1 PEST AND DISEASE DATA

Detailed information on neem pests and diseases is contained in section 5. Entries are arranged first by category of causal factor and then alphabetically by pest organism or abiotic condition within each group. The two major factors which currently affect the health of neem, the Oriental scale, *Aonidiella orientalis* and neem decline are described in more detail in Section 4 because of their particular concern.

Each entry in Section 5 contains the name of the pest organism or abiotic disease, the order and family (arthropods only) and any synonym or non-preferred name. Additional information is provided, where available, on the disease and its symptoms, factors affecting its severity and incidence, its importance, distribution and any appropriate control measures. References are indicated in the text. However, there are many gaps in our knowledge concerning the impact of various pests and their distribution, for example, and many entries are correspondingly brief. There are also uncertainties about whether several pest organisms attack neem.

Section 4 discusses the relative importance of neem pests and diseases under the same categories used in Section 5. Annex 1 organises pest and disease information in a different way to assist those trying to diagnose a particular observed symptom. Symptoms of known diseases are arranged according to the parts of the tree on which occur. Pest organisms associated with these symptoms are shown in brackets. This is a preliminary guide aimed at providing some indication of the cause of observed symptoms. It should be stressed that a confirmed diagnosis can only be made where there is accurate identification of any pest organisms and, where appropriate, testing to confirm pathogenicity for suspected pathogenic microbes. However, an early indication of a possible cause may suggest some basic control measures to minimise further disease losses. It should be remembered that some pest organisms affect more than one part of the tree. Finally, a list of pests and diseases of *Melia azedarach* is included in Annex 2 because the literature often confuses these two closely related trees with somewhat similar names.

3.2 LITERATURE SEARCHES

The starting point for literature searches has been the general forest disease lists prepared by Browne (1968) and Gibson (1975), and lists of neem pests and diseases prepared by Tewari (1992) and Ciesla (1993b). There is an inevitable duplication of information between these secondary publications since they derive most of their information from the same limited group of primary or original references. Original observations are cited in Section 4 and elsewhere, wherever appropriate, to clarify the source of information and resolve any confusion about pest and disease status.

Browne (1968) remains the major source of information on neem pests and diseases. He usefully covers animals, fungi, bacteria and parasitic plants though coverage is limited to Commonwealth countries and several of the pest names have been revised (see below). Tewari (1992) is a more recent account of neem pests and diseases while Schmutterer (1990) describes insect pests of neem observed in countries of several continents. Other searches have been made in major bibliographic databases, most noticeably that covered

by TREE CD (CABI). This has provided invaluable access to forestry literature published from the 1930s to the present.

There are a number of recent reports which are cited in this book, including Boa (1992) and Hodges and Beatty (1992). Although these have been widely circulated they might be difficult to obtain. Copies are available in the FAO Forestry library. Two sets of reports (Boa 1995, Boa and Racaut 1994) describe the establishment of surveys to assess neem decline in Niger and scale attack in Nigeria and contain general field observations. These are also available from FAO.

The amount of information of different pests and diseases is not always an accurate indication of their importance. There is only one published account containing original observations on damage caused by the scale insect, *Aonidiella orientalis*, in West Africa (Akanbi, Alebiosu and Alabi 1990), yet this is the most serious insect pest known. An opposite example is given by pink disease caused by the fungus *Corticium salmonicolor.* This is a widespread fungal disease causing cankers, blight and dieback on a number of woody hosts (Browne, 1968). It is referred to in several disease lists and suggested in some to be a major problem on neem, but the most frequently cited reference for this assessment is a much earlier paper by Subba Rao (1936), which was mainly concerned with pink disease on tea.

The majority of observations of neem pests have been made from India, a country with a longstanding network of forest research institutes and good appreciation of neem. There are also several pest and disease records from Nigeria, though these have declined steeply over the last few decades. There are few records from most other West African countries although neem is widely planted. The reasons for this are not clear but seem unlikely to be due completely to the absence of disease. The low numbers or absence of tree pest specialists in many countries is more likely to be an important factor since it is clear that neem is attacked by a wide range of pests present in many countries.

Records of insects and fungi noted on specimens sent to the CAB International Mycological Institute (IMI) and the International Institute of Entomology (IIE) are included in Annex 1, many of which have not been published elsewhere.

A significant number of "neem" pests listed by Ketkar (1976) are in fact records of insect pests on *Melia azedarach,* a close relative of neem. Confusion may have arisen because of the similarity between this name and an older scientific name of neem, *Melia azadirachta.* This name is still used to describe neem in recent publications even though it is invalid and a revised name, *Azadirachta indica,* has been in common use for many years. Many of the spurious "neem" pest records given by Ketkar are inadvertently referred to in Tewari (1992) and an attempt has been made to resolve this confusion in Section 5.

Searches for pests and diseases of *M. azedarach* were conducted using similar sources consulted for neem. These searches were undertaken because of the close botanical relation to neem and possible nomenclatural confusion between the two trees. *M. azedarach* is known by a variety of local names including Persian lilac, Chinaberry (USA), White Cedar (Australia), Syringa (South Africa) and Cinamamo (South America).

3.3 CHECKING SCIENTIFIC NAMES

Accurate naming of pest organisms is essential for correct diagnosis and treatment of diseases. Attempts have been made to check the scientific names of all pest organisms recorded on neem. About thirty of these scientific names have been revised since they were published in original papers and reports which described the disease. These invalid scientific names have been included in Section 5 with a note of their new revised name. Disease information is listed under the new or preferred name in Section 5.

Two indexes were consulted initially for the validity of arthropod names (insects and mites); Insects of Economic Importance (Wood 1992) and a more recent CABI index, the Arthropod Name Index. This is not yet widely available. No comparable indices are available for other pest organisms and specialists were asked to check names of fungi and bacteria and fill in the gaps of insect pests that were not included in the above two lists.

While every effort has been made to identify and use valid names, the fluidity and flux of different taxonomies will inevitably result in further name changes. If in doubt - consult a taxonomist!

4. OVERVIEW OF IMPORTANT PESTS AND DISEASES

There are over 150 pest organisms which have been recorded on neem (Tables 1) but only a few of these are of any significance. Some pests can cause considerable local damage, such as attacks by the tea mosquito, *Helopeltis antonii,* in southern India and defoliation by insect pests *Eurema* sp. and *Solenopsis* sp. in other parts of India, but there are only two agents which cause major and widespread concern; the scale *Aonidiella orientalis*, and neem decline (le dépérissement du neem), an abiotic disease. A considerable amount is known about these problems as a result of recent studies funded by US AID, ODA and FAO. They are described separately in this section at some length because of their particular importance.

TABLE 1
NUMBER OF BIOTIC PEST ORGANISMS RECORDED ON NEEM

CLASS	NUMBER OF SPECIES
PLANTS	
Bacteria	2
Fungi	31
MLOs	1
Parasitic plants	3
ANIMALS	
Molluscs	1
Insects and Mites	114
Birds	1
Mammals	3

4.1 ABIOTIC DISEASES AND CONDITIONS

Neem is susceptible to a number of known abiotic influences. Benge (1988) provides a useful account of the effect and importance of various abiotic factors on neem growth. These factors include waterlogging (Anon 1963 and Nema and Khare 1992), periods of low temperatures (< 4 °C) and pollution. Fire damage is widespread in Nigeria and Niger though rarely extensive and often limited to individual trees with small areas of affected foliage. Competition between trees planted too close together can also lead to a general reduced vigour and poor growth that characterises the usual response to abiotic factors. Spacings of 4m x 4m and less were associated with poor growth of trees in several northern states of Nigeria, observed by the present author in extensive travels in 1994. There is anecdotal evidence from India to suggest similar experiences in attempts to establish neem plantations in Gujarat.

Hard pans and use of poor nursery stock with congested root systems are commonly cited reasons for poor establishment of tree seedlings but there are other more complex events which can reduce growth and lead to a general loss of leaves - the most common individual symptom associated with abiotic conditions.

While many factors can influence the health and vigour of neem, only one particular condition, neem decline, has been described as a separate and distinct abiotic disease. It is one of the two major factors which affect the health of neem. Its status and existence is disputed by some who say that the "symptoms" of neem decline are in fact normal occurrences that might be expected within an acceptable phenological spectrum. They argue further that neem decline is thus a passing phase and that trees will eventually recover from the excessive leaf loss seen in many trees. There is as yet no unequivocal evidence to suggest that this does happen though there are undoubtedly different degrees of decline. Whatever the interpretation of neem decline, there are still many unanswered questions which require further long-term study.

NEEM DECLINE

The following information is taken from original reports prepared by Boa (1992) and Hodges and Beatty (1992). These were the first technical reports to describe the characteristics of neem decline and suggest a possible cause based on available evidence. A useful summary of neem decline has been published by Ciesla (1993a). More recent observations were made by the present author during a six week visit to Nigeria and a four week visit to Niger in 1994 and are contained in several FAO field documents.(Boa 1995, Boa and Racaut 1994).

HISTORICAL BACKGROUND - Neem decline was first reported from a farm near Sani-Tanko village, 80 km northwest of Dakoro in the central southern zone of Niger. Several trees died suddenly but observations elsewhere by experienced foresters working for aid organisations in Niger, suggested widespread disturbances to the normal growth of neem. This caused considerable concern and prompted international action to study these events in more detail. Several short consultancies took place in 1991 and 1992 but no further studies were undertaken until mid 1994, when survey plots were established to monitor decline in Niger. The initial accounts of neem decline indicated a sudden and widespread occurrence of these abnormal growth features around 1990 in Niger but there is some evidence that similar events may have occurred before this time in Nigeria. There are accounts of yellowing of neem from Nigeria in 1952 by McKay, for example, and mortality of young neem trees.

SYMPTOMS - The main symptom associated with neem decline is an abnormal loss of leaves which may be associated in severe cases with a dieback of branches. This may be preceded by a yellowing and premature senescence of foliage, but this is most common at the end of the dry season. The most distinctive feature which can be used to diagnose decline, which is present throughout the year in severely affected trees, is a pronounced terminal tufting of branches which have shed all their lower leaves. These bare branches, still alive, but with small groups of reduced-size leaves at their apex are referred to as "giraffe necks" (Fig 4). However, tufting of a less exaggerated form is also common on otherwise healthy trees (Fig 5). It is not clear where the transition line between healthy tufting and decline giraffe necks should be made and long term observations of neem tree survey plots will help to resolve this diagnostic issue. Pronounced giraffe neck formation leads to the development of a sparse and open crown (Fig 6). Tufting has also been observed on *Melia dubia* in Karnataka, India where there were indications of stress; it is also been seen generally in poorly growing *Melia azedarach*.

Early assessments suggested that a reddening in the bark and gummy exudates from young shoots were also symptoms of decline but both these features occur in trees

Figure 4 - Thin crowns and tufts of new growth characterize the "giraffe's neck" appearance of declining neems (Photo by W.M. Ciesla).

Figure 5 - A less exaggerated pattern of tufted branches in a neem forest planting near Tera, Niger (Photo by W.M. Ciesla).

Figure 6 - Stages of neem decline; upper left - healthy neem, upper right - neem tree with tufted foliage, lower left - neem with "giraffe necks," lower right - neem with branch dieback and very little foliage (Drawings by Mike Bigger).

without any abnormal loss of leaves, though to a lesser degree. The reddening is associated with a build up of resinous material under the bark; gummy exudates are produced by glands at the base of leaf stalks. Neither is a distinct diagnostic feature and they are no longer thought to be important in neem decline (Ciesla and Donaubauer 1994).

The bare portion of branches below the isolated terminal leaf tufts is still alive. Sprouting may occur from this region following the onset of good rains and suggests that trees with decline may recover. Long-term monitoring of trees is required to confirm this. Pollarding of trees is known to have a similar effect in trees with decline symptoms (Fig 7). The new branches grow more vigorously and develop healthy foliage. However, it has also been said that these new shoots eventually lose their leaves and develop giraffe necks. Long term observations are also needed to investigate this. There is no evidence of any root damage or death in trees with distinct decline symptoms.

Poor nursery stock, when planted out, will fail to grow well. Roots become congested when seedlings are pot-bound and this leads to reduced growth, weedy form and usually death of the tree. Decline is seen in trees of all ages and has clearly affected trees which have previously grown well. This indicates a rather sudden change in growth vigour which cannot, particularly in older trees, be explained by congested root systems.

Dieback occurs in trees with decline but is more commonly associated with urban trees whose root system has been disturbed by adjacent construction activities. Some trees with dieback show otherwise full crowns, with green healthy looking foliage and no development of giraffe necks. Dieback is also linked to fungal attack (see *Botryodiplodia theobromae*) which is thought to occur mostly on weakened trees predisposed to pest attack. However, the symptoms of dieback in declining trees show a different type of symptom to that normally associated with a fungal infection. Dieback caused by a fungal infections has a clear distinction between dead and healthy tissue whilst there is a general graduation between dead and living tissues on branches with dieback in declining trees.

INFLUENCING FACTORS - The cause of neem decline is still open to speculation though there is no evidence of the involvement of any primary pest organism. There is a suggestion that the development of decline is a response to long term drought stress but this will require further detailed study before the long-term effects of drought stress can be fully evaluated. An initial analysis of rainfall patterns by Hodges and Beatty (1992) showed an initial link between reduction in annual rainfall and the appearance of neem decline. Fungal and virus pathogens have been investigated but no obvious candidates have been identified. Nor do the symptoms of neem decline suggest that they might be involved. MLOs have also been considered, though more in hope than certainty! None have been identified. Soil conditions, waterlogging and other factors have been considered as factors which might influence abnormal leaf loss but no association between these factors and neem decline has been positively identified.

SEVERITY AND INCIDENCE - Neem decline is present across the southern belt of Niger and in all the northern states of Nigeria. It has been observed in Chad and northern Nigeria. Other reports suggest that it is present in Mali and Burkina Faso though these have still to be accurately confirmed. Decline occurs in all situations where neem is planted but it is difficult to state clearly where it is most severe since there are undoubtedly seasonal and annual variations which have still be monitored.

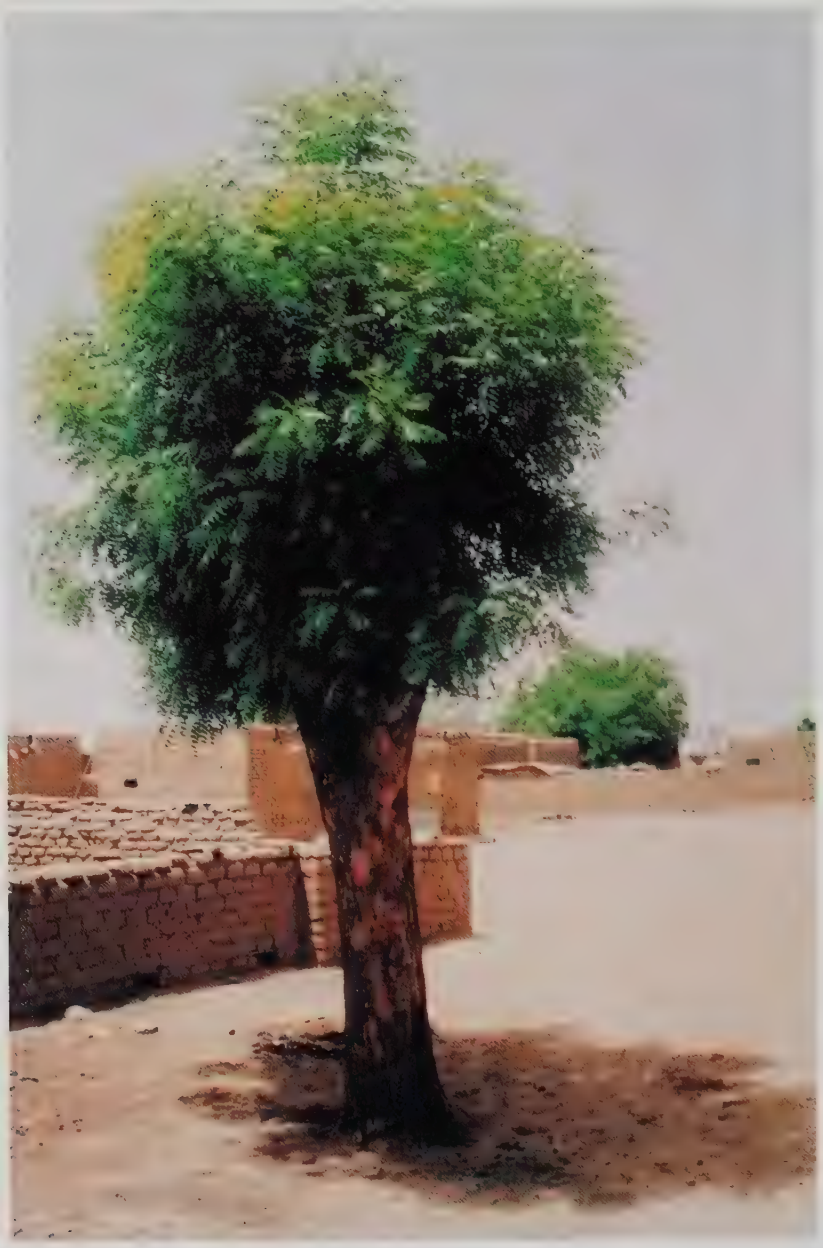

Figure 7 - Neems which have been pollarded typically have dense crowns while neighbouring trees may express symptoms of decline (Photo by W.M. Ciesla)

RELATED OBSERVATIONS - A report by McKay (1952) from Nigeria describes mortality of young neem and yellowing of foliage which took place following the end of the rainy season. Cultivation (hoeing) of the ground under the neem helped to mitigate yellowing and mortality. Similar yellowing was observed in the Maggia valley in Niger at the beginning of the rainy season by the present author in 1994. There was some thought that this might be linked to waterlogging.

Yellowing of foliage in (mature) decline trees can be a prelude to premature leaf drop but it is most common at the end of the dry season - several months after the time described by McKay. McKay speculated that yellowing and death of young neem was linked to poor aeration of soils and iron deficiency; trees growing in richer soils were less prone to yellowing. There is also a note of an unusual die-back of neem which occurred in Sokoto plantations (Anon 1945) though the similarity of this to neem decline is unclear.

GENERAL REMARKS - There are general reports of the poor establishment of neem in less than optimal soils and mortality which results from competition of neem planted too close together in plantations. Neem is also susceptible to high water-tables and does not like water-logging.

4.2 ANIMAL DAMAGE (BIRDS, MAMMALS AND MOLLUSCS)

Bird damage was first documented in eastern Nigeria during the author's visit in 1994. Removal of foliage in the upper crown was observed quite widely in small groups of trees. The overall impact was low. Feeding damage by various mammals also appears to be quite widespread. There is no evidence of major damage being caused by this type of feeding. One instance of snail damage has been recorded and appears, like many other nursery diseases caused by common fungi, to be linked to poor management and sanitation in the nurseries.

4.3 BACTERIAL AND MYCOPLASMA LIKE DISEASES

A recent report described *Pseudomonas solanacearum* on neem in Australia. To date there has only been one record of such attack but further monitoring should be carried out to ascertain the extent of this widespread and multi-host pathogen which is known to cause major losses in mainly non-woody species. Current taxonomic thinking has merged two other bacterial pathogens into one *Xanthomonas* species. This pathogen has not been recorded since an initial series of papers described the leaf spot over twenty years ago in India.

4.4 FUNGAL DISEASES

There is no single fungal pathogen which is of unique importance on neem. Several common nursery problems caused by ubiquitous pathogens have been recorded, such as web blight and damping off, but these can be easily controlled through effective management of nurseries and good cultural practices. Other fungal pathogens are associated with known or potential root, shoot and leaf diseases, though none are of individual noteworthy significance. Misleading impressions have been given of the importance of some fungal pathogens, notably *Corticium salmonicolor*, the cause of Pink Disease. This and other common pathogens known to cause severe damage on other woody hosts as well as neem is not an important disease of neem.

4.5 INSECTS AND MITES

Table 2 shows a surprisingly large number of insects which feed on neem. In fact, many of these records indicate a casual association and there are only a few insect pests which are of any importance. The most serious insect pest is the scale *Aonidiella orientalis* but a number of other insects are known to be locally important and may cause serious damage on small groups of trees. Examples include leaf blight and dieback caused by the

sucking damage of *Helopeltis antonii* and defoliation by *Eurema* sp. and *Solenopsis* sp. Insect pests feeding on seeds may have been under-recorded and have a greater significance that previously considered.

TABLE 2
INSECT SPECIES, BY ORDER, ASSOCIATED WITH NEEM

ORDER	NUMBER OF SPECIES
Coleoptera (beetles)	32
Heteroptera (bugs)	3
Hompotera (aphids, scales)	45
Hymenoptera (ants)	2
Isoptera (termites)	6
Lepidoptera (moths, butterflies)	15
Orthoptera (crickets, locusts)	2
Thripidae (thrips)	5

ORIENTAL SCALE, *AONIDIELLA ORIENTALIS*

There is a marked contrast between the amount of published information on scale attacks in Nigeria and Cameroon and the damage that this insect has caused. Severe infestations in Nigerian towns such as Maiduguri and Yola indicate that this insect pest is a major problem, though there is only one publication from Nigeria which describes scale attack (Akanbi et al 1990). Nigerian authorities were quick to respond to discovery of an initial outbreak of scale in Bama, a small border town in Borno state next to Cameroon, but subsequent technical support to follow this up has been hampered by a number of factors. FAO has funded a technical cooperation project, which began in 1994 and there is hope that this work will continue for a suitable period necessary to introduce effective control measures. Where no reference is given, information on pest attacks in Nigeria and neighbouring countries is based on observations made by the author in 1992 (Nigeria, Chad, Cameroon) and 1994 (Nigeria, Niger).

HISTORY - *A. orientalis* was unknown as a major pest of neem until an outbreak occurred at Bama in Borno State, Nigeria, in 1987 (Akanbi, Alebiosu and Alabi, 1990). The scale was seen much earlier on citrus in Garoua, Cameroon as early as 1972 (Brunck, 1988) and why it took so long for it to travel the relatively short distance across the border to Nigeria is not clear. Brunck also described scale infestations of neem throughout northern Cameroon and the author observed heavy infestations in Kousseri and Maroua in 1992 (Boa 1992). There are other intriguing records of this scale on neem, particularly that from Bamako, Mali in 1978 (Brunck, 1988) where it was causing damage. A report of *A. orientalis* on neem in the Sudan in 1974 (Schmutterer, 1990) follows the general movement of this insect pest from northern India through Arabia and further south.

SYMPTOMS - The scale feeds on foliage, petioles and small branches (Fig 8). As infestations build up there is a gradual increase in browning of the foliage, a combination of scale encrustations and drying up of the leaf (Fig 9). This leads to a fringing effect with areas of the lower crown usually being the first to show symptoms. Trees of all ages are

Figure 8 - Heavy infestation of Oriental scale of neem, *Aonidiella orientalis*, on neem foliage and petioles, Maiduguri, Nigeria (Photo by W.M. Ciesla).

attacked. On some trees there is a marked toxic response to the feeding of the scale on leaves: extensive yellow mottling occurs. Heavily infested leaves remain on the tree for some time even after they have died.

Only trees in medium to large towns show significant damage and browning symptoms in the crown (Fig 10). The scale can be found on roadside trees and in small towns or villages but only in very low numbers which never develop any further. No scale build up has been seen in the extensive lengths of shelterbelts planted in northern Nigeria. A link between water stress and scale attack has been suggested by many local officials and by Schmutterer (1990) but it is interesting to note that scale attack is also severe in Yola and Jimeta in Adamawa state where the annual rainfall is considerably higher than Borno state, and trees generally grow much better.

Figure 9 - Browning of the lower crown of a street tree in Kano, Nigeria due to a heavy infestation of *Aonidiella orientalis* (Photo by W.M. Ciesla).

The scale build-up in towns has been linked to depositions of dust on leaves which may affect the feeding activities of natural enemies. There is a very definite link between proximity of the most seriously affected trees to areas of increased human activity. There is some speculation that particularly susceptible of neem in Nigeria to scale attack may be linked to the narrow genetic base of trees introduced over 70 years ago from India.

Scale attack can result in death of trees though there is evidence of fluctuations in build up from one year to the next. Some trees do show at least partial recovery. Pollarding to remove infested branches initially results in good new growth but this rapidly becomes re-infested.

Figure 10 - Row of street trees in Kano, Nigeria, damaged by heavy infestations of *Aonidiella orientalis* (Photo by W.M. Ciesla).

OTHER HOSTS AND GENERAL DISTRIBUTION - Glover (1933) noted the occurrence of this scale on neem in India but it has never been reported as a major pest of neem in its native range. It is a major pest of *Dalbergia* in India and Pakistan in irrigated plantations. The scale is principally a pest of citrus but infests many other trees, numerous shrubs and garden plants: it is widely distributed in the tropics of the eastern hemisphere and is known from India, Kenya, Malaysia, Pakistan and Tanzania (Browne 1968). Observations by Dr Donli (pers. comm.) confirm that many other plants have been attacked by the scale in Maiduguri (northeastern Nigeria) though the main damage is on neem.

DISTRIBUTION - *A. orientalis* has been observed by the author in NDjamena, Chad and from Kousseri in northern Cameroon to Maroua further south; major damage was observed in Maroua in 1992. The scale is also found in Niger though only in Diffa, to the far east of the country, have browning symptoms been observed on trees. Other scales are found on neem (e.g. *Parlatoria crypta* in Maradi and Niamey) which superficially resemble *A. orientalis* but do not result in leaf death or browning of the crown.

An unpublished report by the Lake Chad Basin Commission in 1991 said that *A. orientalis* occurred all over northern Nigeria and throughout southern Niger. Observations by the author in 1994 and discussions with local officials confirmed that scale attack occurs in most of the northern states of Nigeria but with the possible exception of Sokoto, Kebbi and Katsina. Scale attack was worst in Borno and Adamawa states, where the original outbreaks occurred in 1987. However, spread to other states has perhaps been less than is generally though; the scale had only become a problem in the southern part of Bauchi province in about 1991. Attacks in Jigawa and Kano provinces were limited to isolated trees in major towns. There is some evidence to suggest that movement of infested seedlings may have been the cause of an outbreak of scale attack in northern Bauchi state in the later 1980s and on *Melia volkensii* in Kenya in 1986 (Schmutterer 1990). Other records on neem include Burma and Dominican Republic (Schmutterer 1990) and Malaysia and Pakistan since 1989 (IIE).

CONTROL - Control measures in Nigeria have consisted of insecticide spraying and removal and burning of affected branches. Neither strategy has been consistently followed and there is evidence from other scale attacks on trees that insecticide application is unlikely to be effective, tending to kill natural enemies and predators and leading to increases in scale populations. It is also costly and requires usually imported chemicals and the ready availability of trained personnel and equipment for repeated applications. A coccinellid predator, *Chilocorus distigma*, is known from Niger and Nigeria but has no obvious effect on containing scale populations. The best hope for control lies in the development of appropriate classic biological control through the introduction of natural enemies of the scale.

4.6 PARASITIC PLANTS

Mistletoes recorded on neem are of widespread occurrence in their respective countries (India and Nigeria) but their overall impact is unlikely to be high.

5. ANNOTATED DESCRIPTION OF PESTS AND DISEASES OF NEEM

Entries are arranged by pest organism (or name of condition, if no pest organism is involved) under six different categories:

ABIOTIC DISEASES
ANIMALS (birds, mammals and molluscs)
BACTERIA and MYCOPLASMA-LIKE ORGANISMS
FUNGI
INSECTS and MITES
PARASITIC PLANTS (mistletoes)

Pest organisms are listed alphabetically within each category, except for abiotic diseases where entries are arranged alphabetically by name of the condition. Each annotated entry contains the following information: name of pest organism or abiotic disease; order and family (insects and mites only); non-preferred name(s); symptoms; factors affecting incidence; importance; distribution; general remarks. The source of published and unpublished observations is given. Information on some pests is incomplete and this is usually noted by the phrase "no other details are available." This incompleteness makes it difficult to assess pest status, particularly its distribution and impact. Statements about the uncertain status of a pest may also indicate that there is confusion about whether it is a confirmed pest on neem.

The authorities for scientific names are not given here though they can be obtained in most cases from standard texts such as Browne (1968). Although authorities are commonly provided for pest organisms in disease lists they are of limited use and relevance to the average user of lists who does not, particularly in most tropical countries, have access to the highly specialised literature in which the original descriptions of pest organisms are published. It is also difficult to ensure completeness and accuracy for authorities, especially where such a varied group of pest organisms are being considered. Those seeking further advice on the validity of scientific names are advised to contact the relevant CABI institute for further assistance on fungi and bacteria (IMI) and insects and mites (IIE).

The names of several pest organisms have been changed. Synonyms or non-preferred names are included separately in the lists below with a note of the new or preferred name. All information for a pest organism that has changed its name is published under the preferred name. Pests and diseases which occur on neem and other closely related hosts - most commonly on *Melia azedarach,* though there are a few records on *Melia dubia* and *Melia volkensii* - are noted accordingly.

5.1 - ABIOTIC DISEASES

(Neem) Decline

Premature loss of foliage which leads to sparse and thin crowns and formation of "giraffe necks." In their most pronounced form these consist of bare branches, still alive, but with small tufts of terminal leaves. The leaves which comprise these tufts are much reduced in size. At the end of the dry season, when trees are most stressed, abnormal yellowing (senescence) of leaves may be seen, but not normally at other times of year. The condition is not associated with attack by any known primary pest organism and it is

suggested that long term drought stress is the main factor which influences the development of neem decline. It was first identified from Niger in 1990 but has subsequently been observed extensively in the northern states of Nigeria and in Chad and Cameroon. There are still many unresolved questions about the diagnosis and long term implications of decline which are currently being investigated. A fuller account of neem decline is given in Section 3.2. Information is from Boa (1992), Hodges and Beatty (1992) and Ciesla (1993a).

Fasciation

Small to medium-sized branches are distorted and flattened, with increased production of leaf buds. The cause of this unusual growth form, which has been observed by the author and Dr Hodges on isolated branches of occasional neem trees in Niger in 1992 is not known. It is of little or no significance.

Fire Damage/Rapid Wilting of Leaves

The appearance of patches of brown, dried-up leaves in the crowns of both young and trees has been linked to fire damage (Boa 1992) (Fig 11). These symptoms are seen throughout Nigeria and Niger on neem trees growing close to human settlements. There is often evidence of fires at the base of affected trees. However, the pattern of browning is often patchy and can occur higher up in the crown in areas which do not appear to have been directly affected by fire. A comparison with the pattern of damage associated with *Helopeltis antonii* attack suggests that some of the damage initially thought to be fire damage could be linked to feeding by a similar insect, though there is as yet no confirming evidence.

Pollution Damage

Partial "burning" of foliage (patches of brown, dried-up foliage) was associated with the accidental release of methyl-isocyanate in Bhopal (Ram Prasad and Pandey 1985). Surveys of urban trees revealed that neem was one of the worst affected species though trees had recovered two months after the original observations were made. Conversely, Bhatti and Iqbal (1988) found that neem appeared to be least affected of a range of trees by vehicle pollution and was recommended for roadside plantation.

5.2. ANIMALS (Birds, mammals and molluscs)

Ploceus cucculatus (WEAVER BIRD)

Damage to crown appears to result from the removal of leaves to build nests. Bare branches in upper region of crown superficially resemble dieback but there is no evidence that these branches die (Fig 12). Such damage and extensive nesting were seen by the author on neem trees in Borno and Adamawa provinces, Nigeria in July 1994; a tentative identification was made by C. Feare (MAFF, UK) from photographic evidence. Philippe (1993) records *Ploceus* spp. attacking oil and coconut palms where they strip fronds for nesting material and cause significant damage.

Figure 11 - Patch of dessicated neem foliage in Gubio, Nigeria, the result of fire damage (Photo by E.R. Boa).

Figure 12 - Nests and branch dieback on neem associated with heavy populations of weaver birds, Gubio, Nigeria (Photo by E.R. Boa).

Capra hircus (GOAT)

Feeds on foliage. Local damage seen on neem in Nigeria (Roberts, 1965; cited by Browne, 1968) but there is some indication of different degrees of feeding according to provenance of neem. The National Research Council (1992) says that neem is not a preferred browse for goats, which was confirmed by observations of the present author in Nigeria and Niger in 1994. There are also reports of the toxic effects of neem leaves on goats in Sudan (National Research Council 1992). Gope et al (1988) found that application of 200g of neem cake per litre of fluid to tea bushes reduced goat damage.

Cephalophus rufilatus (RED-FLANKED DUIKER)

Minor feeding damage to bark. Widespread on neem in Nigeria (Roberts 1965, cited by Browne 1968).

Hystrix indica (INDIAN CRESTED PORCUPINE)

Feeding damage at the base of trunks, which can eventually kill young neem trees. The distribution of this pest on neem is not noted by either Browne (1968) or the National Research Council (1992). Browne says that damage by *H. indica* may allow the entry of wound fungi, possibly *Ganoderma.* Khan et al. (1992) noted porcupine damage on *Melia azedarach* in Pakistan.

Lepus crawshayi (HARE)

Feeds on the tops of seedlings in nurseries. It has been recorded in Nigeria (Browne, 1968).

Laevicaulis alte (MOLLUSC)

Feeds on stems and leaves of young neem seedlings. Feeding takes place after dusk and can result in the death of seedlings 90-120 cm tall; older seedlings are defoliated and the stem debarked. Older seedlings can survive if suitable control measures are put into effect such as removal of snails and egg masses, wide spacing of poly bags to avoid concealment of the snail, digging of trenches around the nursery which are filled with salt solution. Serious attacks were seen in nurseries in Rajasthan and Gujarat where up to 20% of seedlings were killed. All information is from Ahmed and Yousuf (1994). An earlier report by Tewari (1992) recorded attack by an unnamed mollusc on neem.

5.3. BACTERIA and MYCOPLASMA-LIKE ORGANISMS

MLO disease

Seedling disease reported for the first time in 1994 from Jodhpur, India. Leaves, cotyledons and stem turn white and plants are reported to collapse "within 2-3 days," presumably from the first appearance of these symptoms. The root system of affected seedlings is poorly developed. Different provenances showed varying degrees of mortality (18 - 57%) and disease development. All information is from Srivastava and Neelam Verma (1994). MLO involvement in a witches broom disease of *Melia azedarach* has been confirmed in Paraguay (Brune 1989), Argentina (Munoz et al 1987) and China (Jin et al 1982). The witches' brooms superficially resemble the giraffe neck formations associated

with neem decline. An earlier record of a witches broom on *M. azedarach* in the USA was attributed to virus attack, although no supporting evidence for this cause was given (Spaulding 1961).

Pseudomonas azadirachtae

Non-preferred name, see *Xanthomonas campestris* pv *azadirachtae*.

Pseudomonas solanacearum

Bacterial wilt on young trees. The only record on neem of this widespread plant pathogenic bacterium is by Diatloff et al (1993) from an experimental station in Queensland, Australia. A rapid collapse of leaves took place after a prolonged period of drought and developed on plants initially grown from tissue culture material derived from Senegal. Symptoms occurred only on three year-old plants. *Pseudomonas solanacearum* has an extremely broad host range which includes woody and non-woody plants. The bacterial isolates did not cause disease on artificially inoculated *Melia azedarach*. Further vigilance is needed to ensure that this disease is carefully monitored in other countries though there is currently no indication that it will become a serious problem.

Xanthomonas azadirachtae

Non-preferred name, see *Xanthomonas campestris* pv *azadirachtae.*

Xanthomonas azadirachtii

Non-preferred name, see *Xanthomonas campestris* pv azadirachtae.

Xanthomonas campestris pv azadirachtae

Synonyms: *Pseudomonas azadirachtae*, *Xanthomonas azadirachtae, Xanthomonas azadirachtii*. Bacterial leaf spot and blight. Shot-holes develop when the initial small translucent water-soaked spots coalesce and become necrotic. Leaves may become chlorotic and fall off. No symptoms have been seen on twigs, flowers or fruits. An association between *Pseudocercospora* sp. (also a leaf pathogen) and bacterial leaf spot has been observed. Many other woody hosts, including *Melia azedarach*, did not develop disease symptoms in artificial inoculations with this bacterium. Information is from Srivastava and Patel (1969). They found bacterial leaf spot on neem in Rajasthan at five different locations; the disease was also observed at Jodhpur (Chakravarti and Gupta 1975), Pune in Maharashtra (Moniz and Raj 1967) and Gujarat (Desai et al 1966). Desai et al noted severe attack during the rainy seasons of 1963-1965. Symptoms appeared as small, irregular leaf spots which were translucent and water-soaked. The whole leaf became yellowish then necrotic and finally dried up. Although this disease is frequently cited in lists of neem diseases (e.g. Tewari 1992) there is no indication that it is a serious problem; no reports of bacterial leaf spot and blight since 1975 have been identified. The disease is not known to occur outside India. The original references to this pathogen suggested that there were two different bacterial species involved but the current taxonomic assessment is that they are both the same species.

5.4. FUNGI

Alternaria alternata

Leaf spot and blight disease affecting young plants in the nursery. It has been recorded from nursery beds at Dehra Dun, India. It affects foliage late in the growing season (October/November) often leading to complete death of leaves. The impact of this disease elsewhere is not stated. Information is from Tewari (1992). Browne (1968) does not record this pathogen on neem but says that the fungus is commonly associated with seedling damping-off. It is also a common wound pathogen and attacks hosts which are physiologically or pathologically weakened.

Ascochyta sp.

No disease details are available. Noted from IMI records on neem and on *Melia azedarach* in South America (Viegas 1961). *Ascochtya* species cause leaf spots on various trees (Browne 1968).

Botryodiplodia theobromae

Associated with weeping cankers and dieback. There is clear evidence that it only attacks trees which are already weakened by stress. Recorded by IMI on neem samples from Niger, Ghana and India. Hodges and Beatty (1992) also describe the disease from Niger and there is a confirmed association with weeping cankers observed by Ciesla (unpublished data) from Dogondoutchi, Niger in 1995 (IMI specimen # W5401) (Figs 13-14). The National Research Council (1992) notes a "canker disease that discolours the wood and seems to coincide with a sudden absorption of water after long droughts." It occurs on *Melia azedarach* (Gibson, 1975) and is present on many other woody hosts (Browne, 1968). Note that although *Botryodiplodia theobromae* remains in common use the preferred name for this fungus is *Lasiodiplodia theobromae.*

Calonectria camelliae

Non-preferred name, see *Nectria camelliae.*

Cercospora leucosticta

Non-preferred name, see *Cercospora meliae.*

Cercospora meliae

Synonym: *Cercospora leucosticta*. Leaf spot. There is some confusion about the pest status of this pathogen on neem. Browne (1968) refers to Butler and Bisby (1960) for occurrence of this fungus on neem in India (cited as *C. leucosticta*). Vasudeva (1963) refers to *C. meliae* causing disease on neem in Madhya Pradesh, India but says that all herbarium specimens he examined were *C. subsessilis* (synonym for *Pseudocercospora subsessilis*). Browne (1968) says that *C. meliae* is a synonym for *C. subsessilis* but this is not correct. Gibson (1975) notes *C. melia* on *Melia* spp. The pathogen occurs on *Melia azedarach* in several countries (Fig 15).

Figure 13 - Branch dieback on neem in Dogondoutchi, Niger associated with the fungus *Botrydiplodia theobromae* (Photo by W.M. Ciesla).

Figure 14 - Bleeding canker of neem. The fungi *Botrydiplodia theobromae* and *Fusarium compactum* have been recovered from these cankers (Photo by W.M. Ciesla).

Figure 15 - *Cercospora meliae* leaf spot on *Melia azedarach*. Similar symptoms are associated with related leafspots on neem (Photo by Xicu Ferreira).

Cercospora subsessilis.

Non-preferred name. See *Pseudocercospora subsessilis.*

Cercospora subsessilis var. azadirachtae

Leaf spot on neem in India (Srivastava 1980 - reference not seen). Although *C. subsessilis* is now known as *Pseudocercospora subsessilis*, this varietal name is still valid and has not been revised.

Cladosporium cladosporioides

No disease details are available and pest status is uncertain. Recorded on neem in India by Sarbhoy et al (1986). It is a cosmopolitan fungus, usually occurring as a secondary invader.

Colletotrichum capsici

Leaf spot and dieback. It was observed attacking 60 - 75 day-old neem seedlings in southern India. The leaf spots are brown with off-white centres. It has a low incidence and is not thought to be important. Information is from Sankaran, Balasundaran and Sharma (1984). Gibson (1975) also noted the same pathogen from India. It is a general, unspecialised pathogen occurring on many plants from a wide range of families (Holliday, 1980), including woody legumes (Boa and Lenné 1994).

Colletotrichum gloeosporioides

Leaf spot and blight. It attacks young neem plants in a nursery and can result in defoliation. It was recorded from Dehra Dun, India at the end of September (Tewari 1992). The teleomorph, *Glomerella cingulata,* has been recorded by IMI from India (Hodges and Beatty 1992). The disease is widespread on many tree species and can kill young plants (Browne 1968).

Colletotrichum mali

No disease details are available; pest status is uncertain. Recorded on neem in India by Sarbhoy et al (1986).

Corticium salmonicolor

Pink disease. Twig blight and dieback resulting from girdled branches (cankers). Although this fungus is frequently referred to in disease lists (e.g. Tewari 1992) there is no evidence that it causes major or extensive damage. Most lists refer to a single disease record on neem from southern India (Subba Rao 1936), contained in a paper mainly concerned with pink disease on tea. Tewari (1992) reports pink disease from Rajasthan in India noting an incidence of "100% in Bikaner," though it is not clear how many trees this refers to. The disease is normally associated with high rainfall areas (> 2000 mm) and prolonged periods of high humidity. Although the fungus is widespread and occurs on many woody hosts it is unlikely to pose a threat to neem.

Diatrype azedarachae

No disease details are available; pest status is uncertain. Recorded on neem in India by Sarbhoy et al (1986). Several *Diatrype* species are associated with cankers on other tree species (Browne 1968).

Fusarium oxysporum

Damping off on nursery seedlings. This is a common pathogen in forestry nurseries associated with poor sanitation and management. Reported from Dehra Dun in India where up to 20% mortality was observed (Tewari 1992). Tewari recommends formalin as a soil drench, followed by application of Thiram and Parasan.

Fusarium solani

Causes a wilt of neem seedlings. There is an initial yellowing and dropping of leaves followed by browning of branches. Roots discolour black and decay. Reported on 75 day-old seedlings from nurseries in Kerala, India causing up to 30% mortality. It is considered to be a disease of some importance though its general significance is likely to be low. Information is from Sankaran et al (1986). The disease has also been recorded by Shukla (1992) from Dehra Dun, India on 2 month-old seedlings. Symptoms began as water-soaked regions at the collar region eventually girdling the stem and leading to sudden drooping of leaves with withering tips. Humid conditions, water-logging and shade increase disease incidence. Mortality of up to 28% of seedlings can occur, and varies according to provenance. Shukla (1992) suggested that the fungus could be seed-borne.

However, the fungus is commonly soil-borne and disease outbreaks are normally associated with poor nursery practices.

Ganoderma lucidum

Root rot. Although there are several general references to this pathogen, most cite Bagchee and Bakshi (1950) as the source of their information. They say that *G. lucidum* is common and damaging on neem in India but offer no detailed information on the disease. Bakshi (1957) supplies no additional information and is mainly concerned with diseases of *Acacia catechu*. The disease has been noted from Dehra Dun and Uttar Pradesh in India (Tewari 1992). This root rot is also found on *Melia azedarach* (Browne, 1968). Feeding damage by mammals at the base of the trunk might facilitate entry of *G. lucidum*.

Glomerella cingulata.

Recorded by IMI, this is the teleomorph of *Colletotrichum gloeosporioides* (see above).

Helicobasidium sp.

Root pathogen. Gibson (1975) notes an IMI record from the Sudan. *H. purpureum* has been recorded on *Melia azedarach* by Gibson. Feeding damage by mammals at the base of the trunk might facilitate entry.

Lasiodiplodia theobromae.

See *Botryodiplodia theobromae* for disease details. The latter is the non-preferred name for this fungus although it is still in common use.

Nectria spp.

N. camelliae (synonym *Calonectria camelliae)* and *N. episphaeria* have been recorded by IMI on neem but no disease details are available. Pest status is therefore uncertain. However, *Nectria* species are associated with canker production on a wide range of woody hosts (Browne 1968).

Oidium sp.

Powdery mildew, leaf disease. *Oidium* sp. has been recorded by IMI from Pakistan (Gibson 1975) and Pune, India by Butler and Bisby (1960) but there is no evidence of major damage. Hodges and Beatty (1992) noted an unidentified powdery mildew on neem in Niger. Tewari (1992) cites Narayamasamy and Ramakrishnan (1971) (reference not seen) for a record of *O. azadirachtae* on neem in India. Viegas (1961) notes *Oidium* sp. on *Melia azedarach* in South America.

Periconia spp.

Generally associated with leaf spots. Srivastava (1977) reported that *Periconia parasitica* produced light brown irregularly shaped leaf spots on neem seedlings in Uttar Pradesh, India. *P. byssoides* and *P. parasitica* were recorded on neem in India by Sarbhoy et al (1986), but their status is unclear.

Phellinus gilvus

Synonym: *Phellinus lichnoides*. Heart rot. Gibson (1975) noted an IMI record from Sudan. Feeding damage by mammals at base of trunk may facilitate entry of the fungus.

Phellinus lichnoides

Non preferred name, see *Phellinus gilvus.*

Phoma abdita

Stem necrosis. Gibson (1975) noted an IMI record but no other details given. Pest status is therefore uncertain.

Phoma jolyana

Twig canker and leaf spot. It can cause severe cankers on twigs and leaf damage. These leaf spots differ from *Pseudocercospora* infections in that they are large and the necrotic tissue falls out leaving a shot-hole. This new disease record is from Punjab city, India (Singh and Chauham 1984).

Phomopsis spp.

Twig blight and limited dieback. A *Phomopsis* sp. recorded on neem from Dehra Dun, India is of minor importance (Tewari 1992). *P. abdita* was recorded by IMI but no other disease details are available. Pest status is uncertain. *Phomopsis* sp. occurs on *Melia azedarach* in South America (Viegas 1961)

Physarum nicaraguense

No disease details are available, pest status is uncertain. Recorded on neem in India by Sarbhoy et al (1986).

Pseudocercospora subsessilis

Synonym: *Cercospora subsessilis*. Leaf spot. Sankaran et al (1986) described symptoms as dull brown spots with dark brown borders - spore bodies appear on lower surface of leaves - on 75 day-old seedlings and older trees in Kerala, India. Hodges and Beatty (1992) say that lesions are dark reddish-brown, circular to angular, and that abundant sporulation is common on the lower surface of leaves. The amount of damage caused does not normally warrant control measures. Gibson (1975) notes that whilst the fungus has been widely recorded on neem (he lists Sudan, Jamaica, India, Pakistan and Hong Kong) it does not appear to have caused severe host damage. Gibson says that *P. subsessilis* is a common pathogen within the Meliaceae and has a wide distribution in the tropics and sub-tropics. Other records of the disease include Ecuador (Hodges and Beatty 1992), Sierra Leone (IMI), Somalia (Castellani and Mohamed 1984) and Jamaluddin and Jabalpur social forestry plantations in India (Mehrotra 1990). Mehrotra adds that the leaf spot attack is severe from December to March when damage is exacerbated by the winter rains. The fungus also attacks tender shoots and young fruits. Harsh, Tiwari and Nath (1989) record "*Cercospora* spp." on neem in India. *P. subsessilis* also occurs on *Melia azedarach* (Hodges and Beatty 1992).

Pseudocercosporella sp.

No disease details are available. Record is from IMI.

Rhizoctonia solani

Web blight on seedlings in nurseries. Mehrotra (1989, 1990) says this is a destructive disease causing damage in Assam and Uttar Pradesh, but it is also described by Sankaran, Balasundaran and Sharma (1986) from Kerala, India. Initial symptoms appear as water-soaked greyish blotches on lower leaves growing close to the ground. A white cottony mycelium develops, spreading over the foliage of adjacent plants giving a web-like appearance. Sclerotia (fungal resting bodies) form only where white mycelial strands are produced. Up to 10% of plants die at first but this can increase to 25-30% by the end of the growing season. The disease stunts growth of the seedlings and restricts leaf development. Effective control can be readily achieved by a combination of sound cultural and sanitation practices. Poly (plastic) pots are recommended for raising seedlings rather than seed beds. *R. solani* is a common pathogen of a wide range of woody and non-woody hosts and its occurrence and severity reflects the quality of management in nurseries. Mehrotra (1989) notes web blight on *Melia azedarach* in India.

Sclerotium rolfsii

Leaf blight and stem rot of nursery plants. Sankaran et al (1986) described this common pathogen on neem in Kerala, India where it was seen attacking 2 month old seedlings. At first, minute off-white lesions with pale brown concentric zonations develop on the leaf which coalesce to result in complete leaf blight. An initial leaf yellowing and wilting eventually leads to the development of water soaked lesions in the collar region or other parts of the stem. At a later stage, stem lesions become sunken and decayed and the whole plant dies. Stem rot occurred in 60-75 day old seedlings and caused up to 30% mortality. Sclerotia are produced. Disease development was exacerbated by crowding of seedlings, high shade and over-watering. Good nursery management and sanitation help to reduce disease losses.

5.5 INSECTS and MITES

Acromyrmex sp. (Hymenoptera: Formicidae)

Leaf cutting ants. They are common defoliators of neem in Central and South America (National Research Council 1992), specifically Ecuador and Nicaragua (Schmutterer 1990). They generally occur only in the New World according to Kranz et al (1977), although they do not record neem as a host.

Adoxophyes aurata (Lepidoptera: Tortricidae)

Leaf weber. Caterpillars spin two or more leaves together. There is no evidence of major damage on neem. They are occasional in Asia and Africa, observed on neem in the Philippines, Indonesia and Papua New Guinea and also on *Melia azedarach,* where considerable leaf damage can occur (Schmutterer 1990).

Agonoscelis versicolor (Heteroptera: Pentatomidae)

Bug on neem but not known to cause any damage. Nymphs feed mainly on millet but adults migrate to a variety of trees (e.g. *Cassia siamea, Eucalyptus camaldulensis*, *E. torelliana* and neem) where they go through a resting stage with no feeding (Browne, 1968). It is a common associate of neem in the savanna zone of Nigeria (Roberts, 1965) and is found throughout West and East Africa (Roberts 1969). There are indications of damage to eucalypts in Kenya (Browne 1968).

Alcis variegata (Lepidoptera: Geometridae)

Synonym: *Boarmia variegata*. Defoliator of young plants. The (looper) larvae feed on leaves and defoliate them completely. Severe attacks have been recorded in neem nurseries in Gujarat and Rajasthan, noted as a new record for India (Tewari 1992).

Aleurocanthus woglumi (Homoptera: Aleyrodidae)

Whitefly recorded by IIE on neem samples from Malaysia. No other details are available; pest status is uncertain.

Aleuroplatus sp. (Homoptera: Aleyrodidae)

Whitefly recorded by IIE on neem samples from Madagascar. No other details are available, pest status is uncertain.

Aleurothrixus floccosus (Homoptera: Aleyrodidae)

Whitefly recorded by IIE on neem samples from Gran Canaria, Canary Islands. No other details are available. Pest status is uncertain.

Anoplocnemis curvipes (Homoptera: Coreidae)

Not known to cause damage. Observed on a number of exotic tree species, including neem, and widespread in young plantations of the savanna region of Nigeria (Roberts 1969). It is most common at the end of the rains. Adults occur at the beginning of the dry season.

Anoplophora chinensis (Coleoptera: Cerambycidae)

Stem borer and tunneller. Tewari (1992) cites Ketkar (1976) for the occurrence of this longhorn beetle on neem "in Japan" but this information was not found in the Ketkar report. Browne (1968) says that the larvae of *A. chinensis* tunnel beneath the bark of *Melia* sp then into the wood where they pupate. It is an occasional pest of *Casuarina equisetifolia* in Hong Kong. It is an important pest of *C. stricta* in Taiwan. Browne notes its occurrence from Burma, China (on poplars), Japan and Korea though neem is not an acknowledged host. Pest status on neem is uncertain.

Aonidiella inornata (Homoptera: Diaspididae)

Scale recorded by IIE on neem samples from Malaysia. No other details are available; pest status is uncertain.

Aonidiella orientalis (Homoptera: Diaspididae)

Synonym: *Aspidiotus orientalis*. Scale which feeds on foliage, young stems, flowers and fruits. Severe attacks can lead to major defoliation of mature trees and associated dieback can result in death of trees. However, heavily infested leaves remain on the tree for considerable periods of time even after they have turned brown. Infestations have been recorded from a number of different countries but significant and widespread damage has only been noted in north Cameroon and the north-eastern states of Nigeria. The scale was first recorded on citrus seedlings in Garoua, Cameroon in the early 1970s but did not apparently become a serious pest until 1987 when a major outbreak was first reported from Bama in Borno state, Nigeria. The most serious infestations only occur on trees in medium to large towns although the insect can also be found in very low numbers on occasional trees in rural areas. Scale attack has been linked to tree stress (particularly drought stress) though recent observations by the present author show that heavy infestations also occur on trees in Adamawa, where the rainfall is much higher than Maiduguri. Neem trees in Nigeria appear to be particularly susceptible to scale attack with some trees showing extensive mottling, a toxic reaction to saliva injected by the scales, and this may be linked to the narrow genetic base of the tree which has been established from very limited introductions. A more detailed account of scale attacks by *Aonidiella orientalis* can be found in Section 4.6. Information is from Akanbi et al (1990), Boa (1992) and Ciesla (1993a).

Apate monachus (Coleoptera: Bostrichidae)

Stem borer. Young adult beetles attack living trees (usually in the dry season) which are at least 1 year- old, selecting the fastest growing ones (Fig 16). Trees usually recover but there is a loss of increment and damage to stem wood. Attack is readily recognised by the presence of large circular holes in the trunk and branches (Fig 17) and dust piles on the ground below. Galleries always run upwards and are often enlarged to form flattened irregular chambers. This insect occurs throughout Nigeria; information is from Roberts (1969). It also occurs in the Dominican Republic (Schmutterer 1990), Niger (IIE) and Ghana (Jones and Roberts 1959) but is not known from India (Tewari 1992). *Apate monachus* is a pest of coffee in Kenya and Tanzania and is found throughout Africa on many woody hosts and has been introduced to West Indies and Brazil. It has been recorded on *Melia azedarach* in Uganda (Browne 1968).

Apate terebrans (Coleoptera: Bostrichidae)

Stem borer. Adults tunnel to feed in small stems and branches of healthy trees, killing them or more usually weakening them so that they are easily wind damaged. It has been recorded on neem in Ghana, where there were occasional instances of severe damage to young stems and branches of neem. It is said to occur throughout Africa south of Sahara on several forest tree hosts, including *Melia azedarach* in Uganda (Browne 1968).

Aphis gossypii (Homoptera: Aphididae)

Aphid feeding on foliage. It was recorded on neem in the Philippines and the Dominican Republic by Schmutterer (1990) but there was no evidence of major damage. The cotton or melon aphid is very widely distributed but is of minor importance in forestry according to Browne (1968).

Figure 16 - Adult *Apate monachus* and gallery in neem, Niger (Photo by C. Hodges).

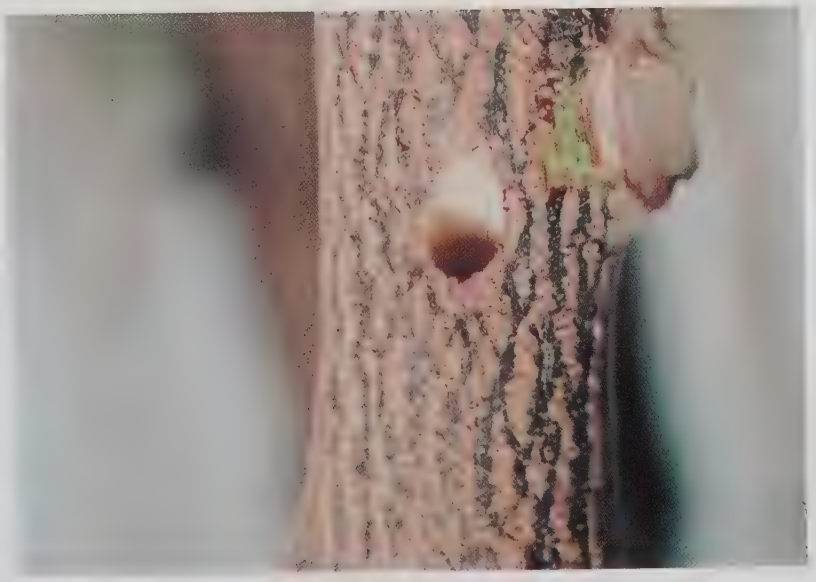

Figure 17 - Entrance hole of *Apate monachus* on neem in Niger (Photo by C. Hodges).

Aphis spiraecola (Homoptera: Aphididae)

Aphid recorded by IIE on neem samples from the Dominican Republic. No other details are available. Pest status is uncertain.

Apirocalus mus (Coleoptera: Curculionidae)

Leaf feeder which prefers trees that are stressed. Feeding results in yellowing of leaves. It has been observed on neem in Papua New Guinea and Burma (Schmutterer 1990).

Araecerus fasciculatus (Coleoptera: Anthribidae)

Seed borer. The only record of this pest on neem is in a list by Benge (1988) who cites a USDA report by Warthen (not seen). No other details are available and its pest status on neem is therefore uncertain. Browne (1968) says that *A. fasciculatus* occurs in India, Pakistan and Malaysia but is also a widely distributed pest of stored seeds, particularly Leguminosae. It is a common pest of coffee and cocoa beans. Infestation occurs when fruit is attached to trees. Eggs are laid in pits gnawed in fruit. Larvae may hollow out several seed before pupating in one. Infestation also occurs in stored seed. Browne said this must be regarded as pest of great potential importance on stored forest seed, especially legumes, but there is no current evidence to suggest that this is a major pest of neem seed.

Araecerus suturalis (Coleoptera: Anthribidae)

Seed borer. Life cycle is similar to that of *A. fasciculatus*. It is a polyphagous seed borer which occurs on neem in India and Pakistan. It also occurs on *Acacia* and *Ficus*. It breeds continuously except in the coldest months and is most abundant in spring and autumn. Information is from Browne (1968).

Ascotis imparata (Lepidoptera: Geometridae)

Moth recorded by IIE on neem samples from India. No other details are available. Pest status is uncertain.

Ascotis selenaria (Lepidoptera: Geometridae)

Leaf feeder. Pest status on neem is uncertain. Tewari (1992) says this is a "well known pest of neem" in the Indian sub-continent but Browne (1968), citing the same original reference, notes *Melia azedarach* as a host in India and Pakistan, *inter alia*, and not neem. According to Browne, this is a widely distributed looper moth. The larvae are polyphagous leaf feeders, present in Nigeria (where it prefers eucalypts), Ghana and Uganda on trees other than neem. The reference quoted by Ketkar (1976) of this pest on neem is in fact of *Ascotis selenaria* on *M. azedarach* in the Punjab.

Aspidoproctus bifurcatus (Homoptera: Coccidae)

Scale which infests stems and branches of mature trees. Although not apparently recorded on neem, an unpublished report by Brunck (1988) suggests that this is a potential pest in West Africa. Roberts (1969) and Browne (1968) note attacks by the pest mostly on *Cassia siamea;* this host was also recorded by Le Pelley (1959) in Tanzania. It infests

stems and branches of mature trees and can be a serious problem in some years, even killing trees. It occurs throughout the savanna zone of Nigeria (Roberts 1969). Browne (1968) adds that the scale usually infests scattered, mature trees but widespread outbreaks have occurred. It has a widespread distribution, including Ghana.

Aspidiotus orientalis

Non-preferred name, see *Aonidiella orientalis.*

Berginus maindroni (Coleoptera: Mycetophagidae)

Recorded by IIE in neem fruit received from Bangladesh. No other details are available. Pest status is uncertain.

Boarmia variegata

Non-preferred name, see *Alcis variegata.*

Borchseniaspis palmae

Non-preferred name, see *Hemiberlesia palmae.*

Bostrychopsis jesuita (Coleoptera: Bostrichidae)

Stem borer and tunneller. The larvae tunnel and feed in branches, reducing sapwood to dust and can sometimes be the cause of death in unhealthy trees. Pest status on neem is uncertain. Tewari (1992) notes that neem is a host outside India, citing Browne (1968). However, Browne says this is an Australian beetle with *Melia azedarach* and *M. dubia* as hosts. Other tree hosts are listed but not neem. Ketkar (1976) suggests that neem is a host but the reference quoted gives *Bostrychopsis jesuita* on *Melia azedarach* in Australia.

Calepitrimerus azadirachtae (Acari: Eriophydae)

Synonym: *Calipitrimerus azadirachtae.* Mite attacking foliage and stems. Mites prefer only tender leaves for feeding. Feeding damage results in minor leaf scars but heavy feeding can result in deformity and drying out of twigs and leaves and can cause severe damage; premature leaf fall. Information is from Tewari (1992). He notes that the mite was found on neem in Delhi and Hasarghatta in India in 1966. A more recent record from Coimbatore in southern India says that heavy infestations of the mite caused a slight yellowing of leaves between August and October. Occasional trees were attacked (Madhavan Pillai and Gopi 1990).

Carpophilus spp. (Coleoptera: Nitidulidae)

Infest seeds and fruit. Several species have been recorded recently on neem. These include: *C. dimidiatus* in Ecuador (Schmutterer 1990). Larvae and adults feed on the seed but usually cannot penetrate the seed coat. *Carpophilus* sp. has been recorded by IIE on neem seeds from Burma. Other species recorded by IIE include: *C. freemani,* Bangladesh, on fruit; *C. mutilatus,* Bangladesh, on fruit and Burma on seeds; *C. pilosellus,* Burma, on seeds. *Carpophilus* species are noted elsewhere as widespread secondary pests in maize cobs, cotton bolls or fruit (Kranz et al 1977).

Ceroplastes spp. (Homoptera: Coccidae)

Wax scale feeding on foliage and stems. *C. ceriferus* is an occasional pest of citrus but also attacks stems, branches, shoots and leaves of numerous trees, including neem (Browne 1968). It is not noted as a major pest on neem in India (Tewari 1992). IIE recorded *C. floridensis* on neem samples from Madagascar but no other details are available. According to Browne (1968) this a widely distributed wax scale, polyphagous, feeding on cashew and mango in India. Neem is the only forest host for *C. pseudoceriferus* in India according to Browne (1968). It is widely distributed in eastern Asia with many hosts. Mango and some *Terminalia* species are also attacked in India according to Tewari (1992), in severe infestations the scales appear as mass of white wax on the host. However, *C. pseudoceriferus* is rarely of much importance as forest pest. *Ceroplastes* sp. has been recorded on neem samples from Papua New Guinea and by Madhavan Pillai and Gopi (1990) from Coimbatore in southern India where there was only a sporadic attack on trees.

Charaxes brutus (Lepidoptera: Nymphalididae)

Recorded by IIE on neem samples from Malawi. No other details are available; pest status is uncertain.

Chrysomphalus aonidum (Homoptera: Diaspididae)

Synonym: *Chrysomphalus ficus*. Scale feeding on leaves. Found on neem in Nicaragua and Papua New Guinea. It is an insignificant pest though it is also known on *Melia azedarach* (Schmutterer 1990). It occurs on more than 630 hosts, of which citrus is the most important (Kranz et al 1977).

Chrysomphalus dictyospermi (Homoptera: Diaspididae)

Scale feeding on leaves. Found on neem in Papua New Guinea. It is an insignificant pest (Schmutterer 1990). It occurs on citrus, mango, tea, coconut palm and other hosts in the Western Mediterranean region, Iran and American tropics (Kranz et al 1977).

Chrysomphalus ficus

Non-preferred name, see *Chrysomphalus aonidum*.

Cleora cornaria (Lepidoptera: Geometridae)

Leaf feeder. Larvae of this looper moth are casual feeders on neem foliage in nurseries and young plants in India where it is of minor importance (Tewari 1992). IIE recorded a *Cleora* sp. on neem samples from an unidentified source.

Coccus sp. (Homoptera: Coccidae)

Synonym: *Lecanium* sp. Scale feeding on foliage and stems. Noted by Tewari (1992) under the category of "minor sap-sucking insects" which have been recorded from neem nurseries and plantations in India. No other details are available. Pest status is uncertain.

Crioceris hamsoni (Coleoptera: Chrysomelidae)

Leaf feeder. Observed on neem in southern India and is of minor importance (Madhavan Pillai and Gopi 1990).

Cryptocephalus aequalis (Coleoptera: Chrysomelidae)

Leaf feeder. Observed on neem in southern India and is of minor importance (Madhavan Pillai and Gopi 1990).

Cryptocephalus hecticus (Coleoptera: Chrysomelidae)

Recorded by IIE on neem samples from Tamil Nadu, India. Species identification is in doubt. No other details are available. Pest status is uncertain. *C. hecticus* adults and larvae attack *Swietenia* in Malaysia (Browne 1968).

Cryptocephalus ovulum (Coleoptera: Chrysomelidae)

Leaf feeder. Adults and larvae feed on various forest tree species, including neem, but rarely cause much damage (Tewari 1992 and Uthamasamy et al 1973). According to Madhavan Pillai and Gopi (1990) it is a casual feeder on neem leaves in Coimbatore, India.

Cryptoflata unipunctata (Homoptera: Flatidae)

Not known to cause damage but it is a common associate of neem in Nigeria (Roberts 1965).

Dialeurodes armatus (Homoptera: Aleyrodidae)

Whitefly (sap-sucker). Recorded on neem in Coimbatore, India and is of minor importance (Madhavan Pillai and Gopi 1990).

Dialeurodes citri (Homoptera: Aleyrodidae)

Whitefly (sap-sucker). All feeding stages produce honeydew. Pest status on neem is uncertain. Tewari (1992) says it has been recorded on neem in the USA but the reference cited by Ketkar (1976), which appears to be the source of this information, gives *Melia azedarach* as the host in the USA. *Dialeurodes citri*, or the citrus whitefly, also occurs on *Melia azedarach* in India (Browne 1968). It is widespread on citrus and also infests foliage of *Syzygium jambos.*

Diaphorina aegyptiaca (Homoptera: Psyllidae)

Psyllid recorded by IIE on neem sample from India; also on citrus and *Cordia rothii* material collected at the same site. No other details are available; pest status is uncertain.

Doliopygus unispinosus (Coleoptera: Platypodidae)

Stem tunneller. This ambrosia beetle normally breeds in fallen or very unhealthy trees and shows no marked host preference. It infests healthy neem in Ghana and results in reduced wood quality (Browne 1968).

Elaphrothrips sp. (Thysanoptera: Phlaeothripidae)

Thrips (sap-sucker). A minor sap-sucker on neem in India according to Tewari (1992).

Enarmonia koenigiana

Non-preferred name, see *Loboschiza koenigiana*.

Endoclita undulifer (Lepidoptera: Hepialidae)

Stem and shoot borer. The polyphagous larvae feed on small stems and branches of numerous trees, particularly small trees (Browne 1968). They bore into the stem and hollow out long tunnels axially. In saplings it is common to find only one larva per tree with tunnels up to 60 cm long and 1 cm in diameter running down to ground level from point of entry. The larvae feed on surrounding sapwood and bark (Tewari 1992). Although Tewari notes this borer occurring in northern India, Bangladesh and Myanmar neem is not a confirmed host. Browne (1968) does not include neem as a host though *Melia azedarach* is noted. Tewari (1992) cites Ketkar (1976) but this does not contain any information on the pest. The status of this pest on neem is therefore uncertain.

Epitragus sallaei (Coleoptera: Tenebrionidae)

Stem borer. Feeding on stems stimulates production of exudate and can also lead to dieback. Adventitious shoots produced at the base of dead stem region are re-infested. Pest attack can influence flower and fruit development. It has been found on neem in Nicaragua. Information is from Schmutterer (1990).

Erythrothrips asiaticus (Thysanoptera: Phlaeothripidae)

Thrips (flower feeder). It occurs on neem in India according to Tewari, (1992). No other details are available. Pest status is uncertain.

Eudocima fullonia (Lepidoptera: Noctuidae)

Synonym: *Orthreis fullonia*. Feeds on fruits of neem. The adult moth damages fruit by piercing while the larvae can destroy the inflorescence (Tewari 1992). Pest status on neem is uncertain, however, since the two references given by Tewari (Browne 1968 and Ketkar 1976) do not confirm that neem is a host. However, according to Tewari this is a minor pest of neem and is better known as a pest of citrus and other fruit trees.

Eurema sp. (Lepidoptera: Pieridae)

Defoliator. Spectacular damage was caused to young neem trees in plantations in Gujarat, India, where all the foliage was stripped (Tewari 1992). The genus *Eurema* is widely distributed throughout arid and semi-arid regions of India. Some species are important pests of shade trees. Control of this pest in young plantations and nurseries has also been attempted by hand-picking of eggs, larvae and pupae.

Fiorinia coronata (Homoptera; Diaspididae)

Scale recorded by IIE on neem sample from Malaysia (two sites). No other details are available. Pest status is uncertain.

Gryllotalpa sp. (Orthoptera: Gryllotalpidae)

Mole cricket. Members of this genus are well known for feeding on the roots of many woody (pine seedlings, eucalypts and neem) and non-woody plants (rice). There is a suggestion in a report by Roberts (1969) that heavy damage to young neem plants occurred after they were planted out although it is not clear whether this degree of damage was restricted to pine seedlings, which were also attacked. It is recorded as being locally important throughout the savanna region of Nigeria. Roberts (1965) reported earlier that "crickets" had severed the shoots of newly geminated neem seedlings in Nigeria. *Gryllotalpa africana* (African mole cricket) has been recorded as an important nursery pest in Jos, Nigeria on eucalypts and pines but not neem according to Browne (1968). The status of this pest on neem thus remains unclear. Krantz et al (1977) report that the mole cricket is widely distributed in Africa and Asia, and feeds on the roots of many plants. It is also a predator.

Heliothrips haemorrhoidalis (Thysanoptera: Thripidae)

Thrips (sap-sucker). The polyphagous nymphs and adults cause occasional damage in crowded nurseries and dense plantations especially to lower shaded leaves. Infested leaves become blotched brown. Neem in India is one of several forest tree hosts. This thrips is widely distributed in tropical regions and is also a pest of coffee (India) and various fruit trees in many countries but is only rarely important in forestry. Information is from Browne (1968). Tewari (1992) says it is a pest of "moderate intensity" in India.

Helopeltis antonii (Heteroptera: Miridae)

Tea mosquito bug feeding on foliage and other soft parts of tree (Fig 18) This sucking causes a rapid wilt and blight of foliage and branches (Fig 19). Infested tissues blacken and die and young shoots may be killed or deformed. The saliva of the bug, which is injected into the tree, is known to be very toxic and is thought to be the main cause of the wilting. Leaves develop extensive necrotic patches prior to complete collapse. There have been suggestions that secondary fungal attack is also involved in symptom expression but this has not been fully studied. It is important to be aware that unless one is familiar with *Helopeltis* damage it is very easy to diagnose possible fungal or bacterial attack, especially as the bugs are not easily seen on plants. All stages avoid direct sunlight and adults fly readily if disturbed. Eggs are laid in small groups in holes made in soft shoots, petioles, midribs of leaves or sometimes in fruits. The nymphs are orange-coloured, resemble ants, and feed at night. It is a polyphagous bug which feeds on foliage and other soft parts of numerous plants, particularly cashew in western India.

Helopeltis antonii is found in Sri Lanka, India and Pakistan but is only known as a pest of neem in India according to Browne (1968). Krantz et al (1977) note that *H. antonii* also attacks tea, cinchona, avocado, guava and cocoa and has a widespread distribution.

A more recent account is given by Madhavan Pillai and Gopi (1990) who observed a major attack on neem in and around Coimbatore in southern India. About 75% of trees were

Figure 18 - Adult *Heliopeltis antoni* on neem shoots in India (Photo by S.R.M. Pillai).

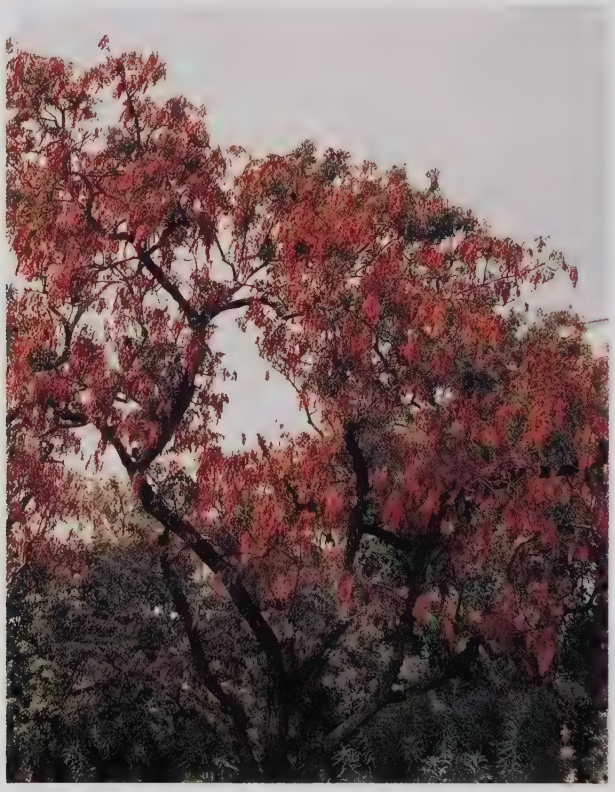

Figure 19 - Neem tree in India showing distal shoot drying due to feeding by *Heliopeltis antoni* (Photo by S.R.M. Pillai).

affected. The present author has also seen attacks in rural areas of Palakkad district in the neighbouring state of Kerala in 1994. According to Madhavan Pillai and Gopi attacks begin in November with insect populations reaching a peak by the end of December. Pest populations remain constant until the middle of January when they decline. However, wilting, foliar blight and dieback do not reach their peak until the following month. Trees showed some recovery by the middle of March when resprouting occurred. On seedlings, tender flush punctures become blackish within hours of attack and start to wilt. All seedlings with infestations died within a month. Pest damage stimulates the production of gum which can help to entrap *Helopeltis* larvae. Madhavan Pillai and Gopi concluded that a wet weather and lower temperatures favour pest build up. They also suggest that the severity of insect attack is related to the amount of weed growth at the base of the tree.

The tea mosquito has been known to attack neem in southern India since 1915 although damage on cashew in the same region (and other countries) is more serious. Stonedahl (1991), in a major review of the oriental species of *Helopeltis,* queries whether many of the records for *H. antonii* (the tea mosquito) are not in fact *H. bradyi*. The National Research Council (1992) book says that *H. theivora* is considered a serious neem pest in southern India. The source of this information is not given but this would appear to be a reference to *H. antonii.*

Hemiberlesia lataniae (Homoptera: Diaspididae)

Scale feeding on leaves and stems. Recorded by Schmutterer (1990) on neem in Fiji where it appears to be of only minor significance. Browne (1968) describes it is an armoured scale which feeds on the sap of leaves, shoots, branches and stems of numerous plants but is rarely of importance as a forest pest. It is common on fruit trees in India where one of the hosts is *Melia azedarach*. Heavy infestation of young trees may cause wilting or deformed growth.

Hemiberlesia palmae (Homoptera: Diaspididae)

Synonym: *Borchseniaspis palmae*. Scale feeding on foliage only? Recorded by Schmutterer (1990) on neem and *Melia azedarach* in Papua New Guinea where it causes only minor damage. There is an IIE record on neem from Malaysia.

Holotrichia spp. (Coleoptera: Scarabaeidae)

Cockchafer feeding on neem. Benge (1988) lists *H. insularis* and *H. serrata* on neem but gives no further details. Benge's information comes from a 1979 USDA report by Warthen which has not been seen.

Holotrichia consanguinea (Coleoptera: Scarabaeidae)

Cockchafer. Larvae feed on roots and the adults feed on foliage. The beetle emerges during pre-monsoon rains in June and oviposits in the soil at the start of the monsoon in July. The larvae start feeding on roots and cause heavy mortality in young seedlings. Adults feed on foliage at night, hiding in soil during the day. This pest occurs on neem in Gujarat, India and is known from Sri Lanka (Tewari 1992). Tewari says it is also a serious pest in teak nurseries in Maharashtra and Gujarat. Browne (1968) says it is a pest of sugar cane, though damage on *Shorea robusta* also occurs.

Homona sp. (Lepidoptera: Tortricidae)

Leaf feeder? Recorded by IIE on neem leaves received from Central Province, Papua New Guinea. No other details are available. Pest status is uncertain.

Hypomeces squamosus (Coleoptera: Curculionidae)

Type of attack not known. Recorded by IIE on neem sample from Malaysia. No other details are available. Pest status is uncertain.

Hypomecis infixaria (Lepidoptera: Geometridae)

Type of attack not known. Recorded by IIE on neem sample from Tamil Nadu, India; species identification is uncertain. No other details are available; pest status is uncertain.

Hypsipyla sp. (Lepidoptera: Pyralidae)

Shoot borer. It attacks neem shoots in southern Australia according to the National Research Council (1992) but further details are not given. However, *Melia azedarach* (white cedar) is more commonly grown in southern Australia where neem is not known to occur. The status of this pest on neem is uncertain. *H. robusta* is the well-known and widely damaging mahogany shoot-borer.

Insulaspis tepleyi

Non-preferred name, see *Lepidosaphes tepleyi*.

Kerria lacca (Homoptera: Kerriidae)

Synonym: *Laccifer lacca*. Scale (sap-sucker). It is better known as the lac insect. A minor pest of neem in India (Tewari 1992).

Laccifer lacca

Non-preferred name, see *Kerria lacca*.

Lasiodactylus chevrolati (Coleoptera: Nitidulidae)

Seed feeder? Recorded by IIE on neem seeds received from Myanmar. No other details are available. Pest status is uncertain. Also noted by Ketkar (1976) who cites a ca. 1916 report from Madras, India of *Lasiodactylus chevrolati* on fallen and fermented fruits of neem.

Laspeyresia aurantiana

Non-preferred name, see *Loboschiza koenigiana.*

Laspeyresia koenigiana

Non-preferred name? *Laspeyresia koenigiana* does not appear in the indices of arthropod names consulted for this paper (INE and ANI). However, *Laspeyresia aurantiana* is a

synonym for *Loboschiza koenigiana.* Information obtained under the name of *Laspeyresia koenigiana* has been placed under *Loboschiza koenigiana*.

Lecanium sp.

Non-preferred name, see *Coccus* sp.

Lecaniodiaspis azadirachta

Non-preferred name, see *Stictacanthus azadirachta.*

Lepidosaphes karkarica (Homoptera: Diaspididae)

Scale recorded by IIE on a neem sample from Malaysia. *Lepidosaphes* sp.(near to *laterochitinosa*) was also recorded on a neem sample from India but no other details are available for either record. Pest status of both species is uncertain.

Lepidosaphes meliae (Homoptera: Diaspididae)

Scale feeding on stems and twigs of neem. The hard, elongate scales are "found in millions" covering stems and twigs and can kill young trees and tender branches. It is not easily seen unless stems are examined closely. In some attacks young trees and tender branches of infested trees dry up. It is occasionally found in association with another scale, *Macropulvinaria*. Ramakrishna Ayar (1925) considered that *Lepidosaphes meliae* could become a major pest on neem, based on his original observations in Coimbatore, India. Subsequent reports do not confirm this. Tewari (1992) notes that *L. meliae* occurs on neem in India but gives no further details.

Lepidosaphes tepleyi (Homoptera: Diaspididae)

Synonym: *Insulaspis tepleyi*. Scale feeding on neem. It is noted in an unpublished report by Brunck (1988) to occur on neem in the Maga region of Cameroon. Pest status is uncertain.

Leptocneria reducta (Lepidoptera: Lymantriidae)

White cedar moth, leaf feeder and defoliator. Tewari (1992) says it attacks neem and cites Browne (1968). However, Browne only notes damage on *Melia azedarach* (white cedar) in Australia. Other Australian reports describe severe defoliation by this moth on *M. azedarach* in the 1950s. Ketkar (1976) also says that *Leptocneria reducta* is a pest of neem but the quoted source of this information records *M. azedarach* as a host in New South Wales, Australia around 1938. Pest status on neem is therefore uncertain.

Loboschiza koenigiana (Lepidoptera: Tortricidae)

Synonyms: *Enarmonia koenigana*, *Laspeyresia aurantiana, ?Laspeyresia koenigiana*. Shoot borer and leaf weber. The larvae bore into shoots and can kill the apical buds, resulting in a limited dieback. The leaves wilt when the insect bores into the petiole. Damage is localised and can result in the stimulation of epicormic branching. Larvae remain under the protection of strands of silk spun in an open web. Information is from Madhavan Pillai and Gopi (1990). Later instars tend to feed in rolled leaves or between leaves spun together

with silk (Browne 1968). There are different opinions on the status of this pest: Browne and Madhavan Pillai and Gopi both say it is of minor significance in India, but Tewari (1992) considers it to be an important defoliator. Tewari adds that attacks by *Loboschiza koenigiana* can lead to heavy gum exudation on damaged shoots. Significant shoot mortality may also occur. The insect is found at all times of the year on neem in Coimbatore, India (Madhavan Pillai and Gopi 1990). IIE and Uthamasamy et al (1973) have also recorded *L. koenigiana* on neem from Tamil Nadu. Although Madhavan Pillai and Gopi say that the insect is present throughout peninsular India it is not clear whether neem is a host beyond southern India. *L. ?koenigiana* has been recorded on neem in Senegal and Benin (Schmutterer 1990). The insect is widely distributed in Asia and Australian on a number of hosts (Browne 1968). Note that there are separate entries in Tewari (1992) for *L. aurantiana* and *L. koenigiana*, which are considered here to be the same insect.

Maconellicoccus hirsutus (Homoptera: Pseudococcidae)

Mealybug feeding on neem. It is noted in an unpublished report by Brunck (1988) to occur in the Maga region of Cameroon and Burkina Faso. No other details are available. Pest status is uncertain.

Macropulvinaria jacksoni (Homoptera: Coccidae)

Scale feeding on foliage and branches. Infestations are characterised by woolly secretions which adorn branches (Fig 20). Excessive honeydew production encourages growth of sooty moulds. According to Schmutterer (1990), infestations occur on stressed trees, such as roadside neem which are regularly pollarded. He has observed it in Niger, Nigeria and Togo. IIE has recorded this scale on neem from Niger and the current author has collected this in Maradi and Niamey, also Niger.

Macrotermes bellicosus (Isoptera: Termitidae)

Termite feeding on young stems. Ring-barking may lead to death of quite large trees though damage is most severe on trees less than 2 years-old. It is an important pest on neem in Nigeria according to Roberts (1965). Browne (1968) adds that it is a subterranean termite recorded on several forest hosts throughout Africa, from Nigeria to Malawi, though it is not clear whether neem is attacked. Eucalypts are more commonly noted as a host in Nigeria. Roberts (1969) somewhat confusingly does not specifically record this termite on neem and a reference to other work on termites in West Africa (Harris et al 1960) only mentions *Macrotermes natalensis* (see below) on neem. The status of this insect on neem is therefore uncertain.

Macrotermes natalensis (Isoptera: Termitidae)

Termite feeding on young stems and roots. It ring-barks trees at the base of the trunk, killing quite large trees though it is most severe on trees less than 2 years- old. It is an important pest on neem in Nigeria and also attacks eucalypts and *Terminalia bellarica*. Information is from Roberts (1965). There is no mention of *Macrotermes natalensis* on neem in Roberts (1969). However, Harris et al (1960) confirm that neem trees were ring-barked and smaller trees were killed by the termite. It is widely distributed in Africa though mainly known for its attack on eucalypts in Nigeria (Browne 1968).

Figure 20 - Infestation of *Macropulvinaria jacksonii* on neem in Niger (Photo by C. Hodges).

Megacoelum esmedonae (Heteroptera: Miridae)

Bug (sap-sucker) feeding on green shoots and leaves. It causes minor damage on neem in India (Tewari, 1992). No other details are given; pest status is uncertain.

Megapulvinaria maxima (Homoptera: Coccidae)

Synonym: *Pulvinaria maxima*. Scale feeding on leaves, twigs and bark. Heavy infestations are conspicuous because of numerous white patches (egg sacs) on leaves, twigs and bark; premature leaf fall and dieback of infested shoots also occurs. Ramakrishna Ayar (1925) describes considerable damage to neem trees in Coimbatore, India. Attacks were most severe during cold weather and the early summer months. There is a heavy production of honeydew and further damage resulting from attendant ants and growth of sooty moulds. The scale can be a serious pest on cotton, mulberry and grape. Browne (1968) says that *Megapulvinaria maxima* is principally a neem pest though it feeds on other trees. It is a large scale insect with a 6-8 week life cycle and occurs in central and southern India. There are up to 8 generations per year. The apterous female feeds voraciously and can produce 600-900 eggs in a white cottony, trailing, ribbon-like egg-sac. Young nymphs swarm over leaves and shoots before settling to feed. Tewari (1992) says that attacks reduce tree vigour and may result in death of the whole tree.

Microtermes mycophagus (Isoptera: Termitidae)

Termite attacking saplings and larger trees. Death is caused by damage to tap roots. It has been recorded from Rajasthan, India by Parihar (1981). Attack is most severe in the dry season. Browne (1968) notes that *Microtermes* is widely distributed in the Old World

tropics. Some of the species commonly injure living plants and destroy roots. They normally infest unhealthy trees or those stressed by drought, for example, but can attack newly transplanted seedlings.

Milviscutulus mangiferae (Homoptera: Coccidae)

Scale recorded by IIE on neem samples from Papua New Guinea. No other details are available. Pest status is uncertain.

Mylabris designata (Coleoptera: Meloidae)

Feeds on neem flowers. Widespread in Nigeria but of minor importance (Roberts 1965).

Mylabris temporalis (Coleoptera: Meloidae)

Feeds on neem flowers. Widespread in Nigeria but of minor importance (Roberts 1965).

Myllocerus dorsatus (Coleoptera: Curculionidae)

Larvae feed on roots and adults are leaf feeders. *Myllocerus dorsatus* is a small, scaly short-snouted weevil. Larvae are believed to live in the soil, feeding on roots, but they are not reported to cause damage to forest trees. Adults feed on the leaves of various trees, including neem, between April and July in India (Browne 1968). Tewari (1992) says this is a minor pest of neem, and this is confirmed by a brief report in Madhavan Pillai and Gopi (1990) which records this pest on neem in Coimbatore, India. IIE has also recorded *M. dorsatus* on neem in southern India.

Odites atmopa (Lepidoptera: Lecthoceridae)

Leaf feeder. This is a minor pest of neem foliage noted from Sri Lanka and India (Browne, 1968).

Odontotermes sp. (Isoptera: Macrotermitidae)

Termite which can ring-bark and fell young trees. Noted from "West Africa" by Harris, Wilkinson and Sands (1960). Ciesla (unpublished data) observed termite tubes to be common on neem in Niger and Nigeria in 1994 and 1995 (Fig 21). Specimens collected from neem in Gaya, Niger were subsequently identified as *Odontotermes* sp. by IIE (collection # 23244).

Odontotermes gurdaspurensis (Isoptera: Macrotermitidae)

Termite which only attacks roots on neem aged six months to 3 years-old. Progressive destruction of the root system leads initially to leaf yellowing and finally death of the plant. Recorded from India by Parihar (1978).

Odontotermes obesus (Isoptera: Macrotermitidae)

Termite attacking young neem plants. Stems are made hollow and there may be partial removal of the root bark. Death of one year-old neem in Gujarat, India has been noted (Tewari 1992), but only moderate infestations are usually found. Severe infestations were

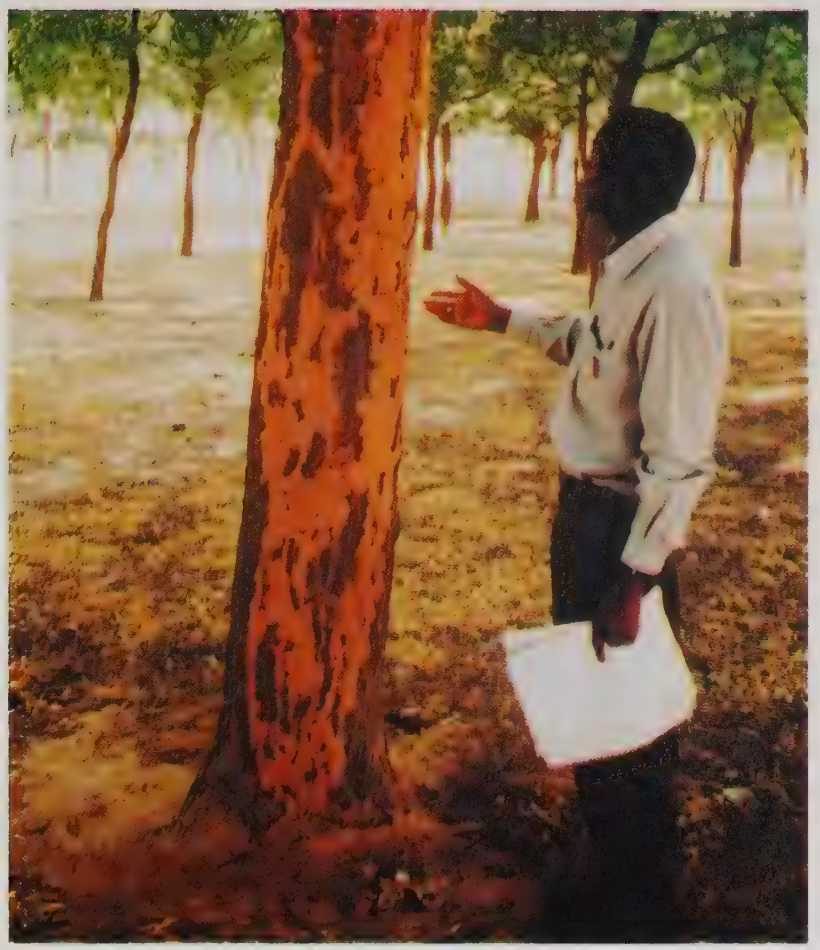

Figure 21 - Termite tubes on the bark of a neem in Gaya, Niger caused by an infestation of *Odontotermes sp.* (Photo by W.M. Ciesla).

(Tewari 1992), but only moderate infestations are usually found. Severe infestations were seen in three year-old neem in Jodhpur, India (Tewari 1992). Browne (1968) notes *Odontotermes obesus* on non-neem hosts in India and Pakistan and says it is a subterranean, mound-building termite. It largely utilizes wood and bark fragments in soil litter but can often be injurious to roots and bark of various trees and crops. It is a pest in coconut plantations and sugar cane and damages nursery stock of trees such as *Casuarina equisetifolia*.

Orthacris simulans (Orthoptera: Acrididae)

Greenish wingless grasshopper observed feeding on mature neem foliage in India. Information is from Tewari (1992) who cites Uthamasamy et al (1973).

Orthreis fullonia

Non-preferred name. See *Eudocima fullonia*.

Oryzaephilus spp. (Coleoptera: Sylvanidae)

Pest feeding on (stored) neem seeds. Schmutterer (1990) notes two species, *O. mercator* and *O. acuminatus* from India, and says these are some of the few insects which develop within the neem seed. Infestation is more serious when neem seed is stored at high temperatures. IIE recorded *O. acuminatus* in neem seeds from Myanmar. Krantz et al (1977) note *O. mercator* (merchant grain beetle) commonly infesting groundnuts. The importance of these pests on neem is uncertain but their widespread distribution may indicate that they are capable of causing significant damage.

Paracoccus sp. (Homoptera: Pseudococcidae)

Mealybug recorded by IIE on neem sample from India. No other details are available. Pest status is uncertain.

Parasaissetia nigra (Homoptera: Coccidae)

Scale recorded by IIE on samples of "*Azadirachta siamensis*" (this would seem to be a reference to *A. indica* ssp. *siamensis* - sometimes known as sweet neem) from Thailand. No other details are available. Pest status is uncertain.

Parlatoria camelliae (Homoptera: Diaspididae)

Scale feeding on flowers and neem seeds in India (Tewari 1992). Ramakrishna Ayar (1925) noted this scale on neem growing in Coimbatore, Tamil Nadu "for the first time from India," but said it was not as serious as either *Lepidosaphes meliae* or *Megapulvinaria maxima* (see above).

Parlatoria crypta (Homoptera: Diaspididae)

Scale feeding on foliage. It is more commonly known as the mango white scale. Schmutterer (1990) recorded it on neem in Niger in 1989 where it was also found by the author (Niamey and Maradi) in 1992 and 1994. Ciesla (unpublished data) collected specimens from both foliage and branches of neem in January 1995 in Niamey and Dogondoutchi, Niger (Fig 22). These were subsequently identified by IIE as *Parlatoria ?crypta* (IIE collection # 23244). The specimens were reported to be intermediate between *P. crypta* which feeds on stems and bark and *P. morrisoni* which feeds on foliage (IIE, personal communication). There are indications that it is widespread on neem in Niger and Nigeria but it is unlikely to be of more than minor significance. IIE notes *Parlatoria* sp. (near *morrisoni*) on neem from India, but no further details are available.

Parlatoria orientalis (Homoptera: Diaspididae)

Scale recorded by IIE on neem sample from Tamil Nadu, India. No other details are available; pest status is uncertain.

Phaedonia areata (Coleoptera: Chrysomelidae)

No known damage, but according to Roberts (1965) this is widespread on neem in Nigeria.

Figure 22 - Stem infestation of *Parlatoria ?crypta* on neem, Dogondoutchi, Niger (Photo by W.M. Ciesla).

Phaenoderus sp. (Coleoptera: Curculionidae)

Found on newly opened leaves. Occurs in Nigeria but is of no importance (Roberts 1969).

Phryneta spinator (Coleoptera: Cerambycidae)

Longhorn beetle, adults of which feed on bark. The larvae are serious borers but are not confirmed pests of neem. Tewari (1992) says it breeds on neem in Africa and cites Browne (1968) and Tooke (1936). Browne does not list neem as a host but does note *Melia azedarach*. Ketkar (1976) also implies that neem is a host tree but his source actually refers to *M. azedarach* as a host in "South Africa and to the north." The status of this pest on neem is therefore uncertain. Tewari says that adults feed on bark without causing any severe injury to the host plant. The larvae are serious borers of a number of woody hosts (e.g. *Ficus* and *Salix* spp). *Phryneta spinator* is widely distributed in tropical and southern Africa according to Browne (1968).

Pinnaspis strachani (Homoptera: Diaspididae)

Scale feeding on leaves, twigs and seeds. Occurs on 1-2 year-old trees but also feeds on leaves of older plants. Large populations may develop but are usually kept under control by natural enemies. Recorded on neem from Philippines (1988), Sudan (1973), Senegal (1987), Benin (1989), Dominican Republic (1988), Nicaragua (1989) and Papua New Guinea (1989). Also on *Melia azedarach* (Schmutterer 1990). The National Research Council (1992) says it is a common pest on neem in Asia, Africa and Latin America but does not quantify the amount of damage. IIE has records of this pest on neem samples from Malaysia (three sites).

Pseudaulacaspis cockerelli (Homoptera: Diaspididae)

Scale recorded by IIE on neem samples from Malaysia. No other details are available; pest status is uncertain.

Pseudococcus gilbertensis (Homoptera: Pseudococcidae)

Mealybug recorded by IIE on neem sample from Tamil Nadu, India. Species identification not certain. No other details are available. Pest status is uncertain.

Pseudococcus maritimus (Homoptera: Pseudococcidae)

Grape mealybug. Nymphs feed on sap of grapes or at the base of vine shoots (Browne 1968). Tewari (1992) notes this pest on neem in Egypt citing Joubert (1943), a bulletin from South Africa and Browne (1968). Ketkar (1976) suggests that neem is a host but his source is actually a report of *Pseudococcus maritimus* on *Melia azedarach* in Egypt. Browne also says that *Melia azedarach* is a host in Egypt and not neem. Its status on neem is therefore uncertain. It is widely distributed, mainly in the sub-tropics, and is known principally as a pest of vines.

Pulvinaria sp. (Homoptera: Coccidae)

Scale infesting stems and crowns. It infests "various dicots," including neem (Browne 1968). It is of minor importance according to Tewari (1992) who describes it is a sap-sucker feeding on stems and crown but does not cause severe damage. IIE notes two accessions of *Pulvinaria* sp. on neem samples from India (Tamil Nadu and Gujarat).

Pulvinaria azadirachtae

Non-preferred name, see *Pulvinaria* sp.

Pulvinaria maxima

Non-preferred name, see *Megapulvinaria maxima*.

Rastrococcus biggeri (Homoptera: Pseudococcidae)

Mealybug recorded by IIE on neem sample from Malaysia. Species identification is not confirmed. No other details are available. Pest status is uncertain.

Schizotetranychus hindustanicus (Acari; Tetranychidae)

Spider mite recorded by IIE on neem samples from Pune, India. No other details are available. Also noted by Ketkar (1976) as a pest of neem in South India (ca 1939 report). Pest status is uncertain.

Scirtothrips dorsalis (Thysanoptera: Thripidae)

Thrips. Adults and nymphs feed on sap of flowers and can cause abortion of ovaries and premature flower drop on neem (Tewari 1992, citing Ananthakrishnan 1973). Browne (1968) describes *Scirtothrips dorsalis* as the Assam thrips common on rubber in Asia, including India and Malaysia. In Assam, it is also found on tea and other crops. Browne does not record either neem or *Melia azedarach* as a host.

Selenaspidus articulatus (Homoptera: Diaspididae)

Scale feeding on leaves. It is of minor significance although it has been recorded on neem in Senegal (1987), Papua New Guinea, Fiji and Benin (all 1989) by Schmutterer (1990). Krantz et al (1977) refer to this species as the Rufous or West Indian scale and note attacks on coconut palm. It is widely distributed in the Old and New World. Host plant range includes *inter alia* citrus and banana.

Siderodactylus sagittarius (Coleoptera: Curculionidae)

Browne (1968) says it is common in savanna woodlands of Nigeria where it feeds on neem and eucalypts. It is not an important pest.

Solenopsis sp. (Hymenoptera: Formicidae)

Fire ants which defoliate trees. A brief report by Raghunath et al (1982) described *Solenopsis* causing serious damage in 3-6 year old neem plants in Hyderabad, India during May 1978. Large number of ants fed voraciously on leaves of neem trees, resulting in complete defoliation. This insect was not found on other hosts. Fire ants are associated with damage to pines in the southern US and can also attend scales, exacerbating damage to the trees.

Sphenoptera sp. (Coleoptera: Buprestidae)

Incidental defoliator. It does not cause any obvious damage according to Roberts (1965), who noted it on neem in Nigeria. Also occurs on *Cassia siamea* and *Eucalyptus camaldulensis* in Nigeria.

Sternocera interrupta (Coleoptera: Buprestidae)

Synonym: *Sternocera reticulata*. Adult beetles are an occasional and incidental defoliator of neem in Nigeria (Roberts 1965 and Browne 1968).

Sternocera reticulata

Non-preferred name, see *Sternocera interrupta.*

Stictacanthus azadirachta (Homoptera: Lecanodiaspididae)

Synonym: *Lecaniodiaspis azadirachta*. False pit scale. A minor sap sucker of neem in India (Tewari 1992). No other details are available. Pest status is uncertain.

Taeniothrips longistylus (Thysanoptera: Thripidae)

Thrips feeding on sap of leaves and shoots in India, also found on sandal (Browne 1968). It is a minor pest according to Tewari (1992).

Tetranychus spp. (Acari: Tetranychidae)

Spider mites. Sap-suckers that are of minor importance and cause little perceptible damage on neem (Tewari 1992). It also occurs on *Melia azedarach* (Schmutterer 1990).

Vinsonia stellifera (Homoptera: Coccidae)

Scale which feeds on foliage. It has been found on neem in the Dominican Republic, Benin, and the Philippines. It also attacks palms and mangoes. Neem attacks are closely associated with infestations of these other hosts (Schmutterer 1990). *Vinsonia stellifera* is widely distributed in the tropics and sub-tropics and is known mainly as a minor pest of mango in Mauritius and Seychelles and West Indies. It also occurs on rubber in Guyana and *Syzygium jambos* in India according to Browne (1968).

5.6 PARASITIC PLANTS (mistletoes)

Dendrophthoe falcata

Semi-parasitic plant which occurs on a wide range of dicot trees and conifers, including neem and *Melia azedarach*. It is particularly injurious to seedlings, and can suppress growth and stunt plants. It is widely distributed in the tropics of the eastern hemisphere, including Sri Lanka, India and Pakistan. It is the most widespread and destructive mistletoe on trees in India and Pakistan. The seed is dispersed by birds. Information is from Browne (1968).

Tapinanthus globifera

Epiphytes and semi-parasitic shrubs which occur in the crowns of trees. They are dependent on their host for water and soil nutrients. An unidentified species on neem is widespread in Nigeria according to Browne (1968). Roberts (1965) says that "*T. globifer*" is common on indigenous trees in Nigeria. Attacks can lead to death of branches and general retardation of growth. More recent observations and collections by the author and W. M. Ciesla (unpublished data) confirm that *T. globifera*[1] is a common epiphyte of neem growing in major towns of north-eastern Nigeria (Figs 23-25). *T. globifer* is assumed to be an orthographic variant - a misspelling - of *T. globifera.* Attacks are also associated with the development of dieback. Browne also records *Tapinanthus pentagonia* on *Melia azedarach* from western Nigeria

[1] Specimens identified by Roger Polhill, Royal Botanic Gardens, Kew, UK

Figure 23 - Neem in Maiduguri, Niger with heavy infestation of the mistletoe, *Tapinanthus globifera*
(Photo by W.M. Ciesla)

Figure 24 - Flower and foliage of the mistletoe, *Tapinanthus globifera* (Photo by W.M. Ciesla).

Figure 25 - Seeds and foliage of the mistletoe, *Tapinanthus globifera* (Photo by W.M. Ciesla).

ANNEX 1

GUIDE TO SYMPTOMS OF NEEM DISEASES AND THEIR POSSIBLE CAUSE

The purpose of this section is to indicate a possible cause of observed symptoms of ill health on neem. It must be stressed that a full and accurate diagnosis requires careful and thorough investigation of all available evidence. Care should be exercised, for example, in assuming a direct association between the occurrence of a pest organism and observed symptoms, particularly where the identity of the pest organism is in doubt. Detailed information on pest organisms and neem disorders are given in Sections 4 and 5.

Symptoms are listed according to the part of the tree on which they occur, but note that pests may affect more than one part of the neem tree. Some pests, particularly insects, may feed on fruits, leaves and branches. The names of pest organisms and diseases are given in brackets after the symptoms.

Roots

* Root disease (***Helicobasidium* sp.**, fungus)
* Root feeding (***Gryllotalpa* sp.**, mole cricket; ***Holotrichia consanguinea***, larvae of cockchafer beetle; ***Myllocerus dorsatus,*** beetle larvae)
* Root rot (***Ganoderma lucidum***, fungus)
* Tap root damage (***Microtermes mycophagus***, termite)

Main Trunk and Branches

* Bark (gnawing) damage near to base (***Cephalophus rufilatus***, red flanked duiker; ***Hystrix indica***, Indian crested porcupine)
* Heart rot (***Phellinus gilvus***, fungus)
* Ring-barking, mostly on young trees [<2 yrs-old]: termite damage (***Macrotermes bellicosus***; ***M. natalensis, Odontotermes* spp.**

Medium, Small branches and Young Shoots

* ?Cankers (***Nectria* spp.**, fungi recorded on neem; no associated symptoms were described but fungi associated with canker development on other woody hosts).
* Canker, also causes leaf spot (***Phoma jolyana***, fungus).
* Cankers girdling branches leading to dieback, blight; pink disease (***Corticium salmonicolor***, fungus).
* Cankers, weeping and dieback (***Botryodiplodia theobromae***, fungus)
* Drying out and death of branches, possible deformity (***Calepitrimerus azadirachtae***, eriophyd mite).
* Fasciation, flattening and distortion of small to medium sized branches (**unknown cause** - abiotic?)
* Feeding damage on younger stems (***Maconellicoccus hirsutus***, mealybug; ***Megacoelum esmedonae***, bug; ***Paracoccus* sp.**; ***Pseudococcus gilbertensis; Rastrococcus ?biggeri,*** mealybugs)
* Scale encrustations, can be associated with dieback (***Aonidiella orientalis*** [also on foliage]; ***Pinnaspis strachani,*** scale insects)

* Shoot borer and dieback, production of epicormic shoots (***Loboschiza koenigiana***, tortricid moth larvae)
* Stem and shoot borer (***Endoclita undulifer***, lepidopterous larvae; ***Hypsipyla* sp.**, mahogany shoot borer; ***Phryneta spinator***, longhorn beetle larvae)
* Stem and twig scale attack, possible death of young trees (***Lepidosaphes meliae***, ***Pulvinaria*** sp. [also on foliage], scale insects)
* Stem blight and dieback (***Phomopsis* spp.**, fungus)
* Stem borers (***Anoplophora chinensis; Apate monachus; Apate terebrans***; ***?Bostrychopsis jesuita***, ***Doliopygus unispinosus; Epitragus sallaei,*** all beetles)
* Stem necrosis (***Phoma abdita***, fungus)

Foliage and Crown

* Defoliation (***Alcis variegata***; ***Ascotis selenaria***, looper moths; ***Eurema* sp.**, lepidopterous larvae; ***?Leptocneria reducta***, moth; ***Loboschiza koenigiana,*** tortricid caterpillars; ***Myllocerus dorsatus,*** adult beetles; ***Solenopsis* sp.**, fire ant)
* Defoliation and leaf yellowing (***Apirocalus mus***, beetle)
* Foliage browning developing from heavy scale infestations, leaf mottling (yellow streaks), ensuing dieback in severe attacks (***Aonidiella orientalis***, scale insect. NB ***Pinnaspis strachani*** may also develop large populations on foliage but no indication that these can cause significant dieback or loss of foliage)
* Foliage browning, rapid, dried up, in patches (***Helopeltis antonii,*** bug; **Pollution damage**)
* Foliage loss and dieback associated with growth of parasitic plants in crown (***Dendrophthoe falcata***, ***Tapinanthus spp***)
* Foliage removed, branches stripped in upper crown *(**Ploceus cucculatus,*** bird damage)
* Foliage removed, eaten and branches stripped at base of tree *(**Capra hircus,*** goat*)*
* Leaf cutting, defoliation (***Acromyrmex* sp.**, leaf cutting ant)
* Leaf damage, defoliation, honeydew production may lead to sooty mould attack (***Macropulvinaria jacksoni***; ***Megapulvinaria maxima,*** scale insects)
* Leaf feeding, brown blotches develop (***Heliothrips haemorrhoidalis***, thrips [nymphs and adults])
* Leaf feeding, general (***Holotrichia consanguinea***, adults of cockchafer beetle; ***Orthacris simulans***, grasshopper; ***Sphenoptera* sp.**, beetle; ***Sternocera interrupta,*** beetle)
* Leaf feeding, minor damage (***Crioceris hamsoni***; ***Cryptocephalus aequalis, Cryptocephalus ?hecticus***, ***Cryptocephalus ovulum,*** beetles; ***Odites atmopa***, moth)
* Leaf spot (brown, circular to angular, abundant sporulation on lower surface); may be also attack on young shoots and fruits (***Pseudocercospora subsessilis***, fungus)
* Leaf spot (water-soaking, shot-holes) and blight (***Xanthomonas campestris* pv. *azadirachtae***, bacterium)
* Leaf webbing - two or more leaves spun together (***Adoxophyes aurata; Loboschiza koenigiana,*** caterpillars of tortricid moth)
* Leaf yellowing, minor scarring (***Calepitrimerus azadirachtae***, eriophyd mite)

* Premature loss of leaves, tufting of reduced-size leaves at end of branches (giraffe necks), possible yellowing; if pronounced leads to open sparse crowns, possible dieback (**Decline**, abiotic disease)
* Wilt in young trees (***Pseudomonas solanacearum***, bacterium)

Flowers, Fruits, Seeds

* Flower and/or seed scale (***Parlatoria camelliae***; ***Pinnaspis strachani,*** scale insects)
* Flower feeder, possible premature drop, failure to produce fruit (***Erythrothrips asiaticus***, thrips; ***Mylabris designata***, beetle; ***Scirtothrips dorsalis***, thrips)
* Fruit feeder (***Eudocima fullonia***, noctuid moth [adults and larvae])
* Infestation of stored seed (***Oryzaephilus* spp.**, beetles)
* Seed and fruit infestations (***Carpophilus* spp.**, beetles)
* Seed borer (***Araecerus suturalis***, beetle)

Seedlings (Nursery problems)

* Collapse of young plants (**MLO**)
* Damping off (***Fusarium oxysporum***, fungus)
* General feeding damage to stems and leaves (***Laevicaulis alte***, mollusc)
* Leaf blight, stem rot (***Sclerotium rolfsii***, fungus)
* Leaf feeder (***Cleora cornaria***, looper moth)
* Leaf feeding, brown blotches develop (***Heliothrips haemorrhoidalis***, thrips [nymphs and adults])
* Leaf spot (brown, off-white centre) and dieback (***Colletotrichum capsici***, fungus)
* Leaf spot (***Periconia parasitica***, fungus)
* Leaf spot and blight (***Alternaria alternata***; ***Colletotrichum gloeosporioides*** - fungi)
* Stem feeder (crickets - most likely ***Gryllotalpa* sp.**)
* Tops eaten (***Lepus crawshayi***, hare)
* Web blight (***Rhizoctonia solani***, fungus)
* Wilt (***Fusarium solani***, fungus)

Insect pests recorded on neem but pest status not known

Whiteflies

Aleurocanthus woglumi
Aleuroplatus sp.
Aleurothrixus floccosus
Dialeurodes armatus. D. citri

Aphids

Aphis gossypii, A. spiraecola

Scales

Aonidiella inornata
Ceroplastes spp.
Chrysomphalus aonidum

Chrysomphalus dictyospermi
Coccus sp.
Fiorinia coronata
Hemiberlesia lataniae, H. palmae
Kerria lacca
Lepidosaphes karkarica, L. tepleyi
Milviscutulus mangiferae
Parasaissetia nigra
Parlatoria crypta, P. orientalis
Pseudaulacaspis cockerelli
Selenaspidus articulatus
Stictacanthus azadirachta
Vinsonia stellifera

Thrips

Elaphrothrips sp.
Schizotetranychus hindustanicus
Tetranychus spp.

ANNEX 2

LIST OF PESTS AND DISEASES ON *MELIA AZEDARACH*

A list of pest organisms recorded on *Melia azedarach* is provided for a number of reasons. Firstly, there still appears to be confusion between *M. azedarach* and neem, resulting in the wrong host attribution of pest and disease records. Ketkar (1976), for example, lists many insect species supposedly attacking neem which were in fact originally recorded on *M. azedarach.* The reason for the confusion is because of an historic similarity between scientific names: neem was previously known as *Melia azadirachta*. This non-preferred name still appears in recent publications despite the change to the currently preferred name of *Azadirachta indica* which took place many years ago.

The second reason for providing this list is to indicate potential pests and diseases of neem. Several pests and diseases are already known to occur on neem and *M. azedarach* and are marked with the symbol *. There is an overlap in ecological range between the two trees and they can be found growing more or less alongside each other in several countries, though neem tends to occur more abundantly in hotter and drier climates whilst *M. azedarach* is common in sub-tropical places such as South Africa (where it is regarded by some as a weed), Paraguay and southern Australia.

Unless a particular disease or disorder of *M. azedarach* is also known to occur on neem there is no other information available in this book other than the reference given in the table below. Where more than one reference exists for a pest or disease record the most reliable source of information is cited, or that reference which contains the most detail.

Synonyms or non-preferred names are not listed separately but indicated after the preferred name.

In contrast to neem, there are many more fungal pathogens recorded on *M. azedarach* than insect pests.

BACTERIA & MLOs

- * ***Mycoplasma disease (MLO)****: e.g. Matsuoka et al., (1986)
  The MLO on neem has not been characterised, and is not necessarily the same as that confirmed and described on *Melia azedarach* (see Matsuoka et al).
- * ***Pseudomonas meliae.*** Bacterial disease which occurs in Japan and Taiwan. Original reference not seen (Ogimi, 1977).

FUNGI

- * ***Ascochyta*** sp *. Viegas (1961)
- * ***Botryodiplodia meliae.*** Gibson (1975)
- * ***Botryodiplodia theobromae*** * (preferred name *Lasiodiplodia theobromae).* Gibson (1975)
- * ***Botryosphaeria disrupta*** (synonyms: *Physalospora abdita; P. fusca*). Hepting (1971)
- * ***Botryosphaeria dothidea.*** Sinclair et al (1989)
- * ***Botryosphaeria obtusa*** (synonym: *Physalospora obtusa).* e.g. Browne (1968)

* ***Botryosphaeria rhodina***. (synonym: *Physalospora rhodina*). e.g. Browne (1968)
* ***Botryosphaeria ribis***. Hepting (1971)
* ***Botrytis rileyi***. Viegas (1961)
* ***Cercoseptoria domingensis***. e.g. Viegas (1961)
* ***Cercospora meliae*** * (synonym: *C. leucosticta*). e.g. Gibson (1975)
* ***Cercospora meliicola***. Viegas (1961)
* ***Corticium koleroga***. Browne (1968)
* ***Diaporthe eres***. Viegas (1961)
* ***Diaporthe tetrastaga-compressa***. Viegas (1961)
* ***Diplodia langloisii***. Hepting (1971)
* ***Eutypa heteracantha***. Viegas (1961)
* ***Eutypella paradisiaca***. Viegas (1961)
* ***Eutypella stellulata***. Hepting (1971)
* ***Fenestella vestita***. Viegas (1961)
* ***Phellinus robinae*** (synonym: *Fomes rimosus*). Gorter (1977)
* ***Fusarium lateritium***. e.g. Sinclair et al (1989)
* ***Fomitopsis meliae*** (synonym: *Fomes meliae*). Hepting (1971)
* ***Ganoderma applanatum***. Gorter (1977)
* ***Ganoderma lucidum*** *. Browne (1968)
* ***Ganoderma pseudoferreum***. Browne (1968)
* ***Gibberella cyanogena*** (probably a reference to *Fusarium sp.*). Viegas (1961)
* ***Gloeosporium meliicola***. Viegas (1961)
* ***Glomerella cingulata*** (teleomorph of *Colletotrichum gloeosporioides*). e.g. Hepting (1971)
* ***Gloniopsis australis***. Viegas (1961)
* ***Glonium microsporum***. Viegas (1961)
* ***Graphium fissum***. Viegas (1961)
* ***Helicobasidium purpureum***. e.g. Hepting (1971)
* ***Helminthosporium meliae***. Viegas (1961)
* ***Hendersonula toruloidea***. e.g. Browne (1968)
* ***Hypochnus roseo-cinctus***. Viegas (1961)
* ***Hypocrea jecorina***. e.g. Stevenson (1975)
* ***Hysterographium portenum***. Viegas (1961)
* ***Kretzschmaria clavus***. Viegas (1961)
* ***Mollisia melaleuca***. Viegas (1961)
* ***Nectria cinnabarina***. e.g. Browne (1968)
* ***Nectria coccinea***. e.g. Browne (1968)
* ***Nectria dealbata***. Gibson (1975)
* ***Nectria episphaeria*** *. Viegas (1961)
* ***Nectria*** sp.. Gibson (1975)
* ***Nectriella pironii***. Sinclair et al (1989)
* ***Oidium*** sp. *. Viegas (1961)
* ***Oxyporus latemarginatus***. Sinclair et al (1989)
* ***Patellina italichroma***. Viegas (1961)
* ***Pellicularia koleroga***. e.g. Hepting (1971)
* ***Peniophora galochroa***. e.g. Stevenson (1975)
* ***Peronospora parasitica***. Hepting (1971)
* ***Phellinus conchatus*** (synonym: *Fomes conchatus*). Gibson (1975)
* ***Phellinus fastuosus***. Gibson (1975)
* ***Phellinus lamaoensis*** (synonym: *Fomes lamaensis*). Spaulding (1961)

* ***Phellinus senex*** (synonym: *Fomes senex*). e.g. Browne (1968)
* ***Phellinus torulosus*** (synonym: *Fomes torulosus*). Hepting (1971)
* ***Phellinus umbrinellus*** (synonym: *Polyporus corruscans*). Gibson (1975)
* ***Pholiota ?crassivela.*** Viegas (1961)
* ***Phoma*** sp.. e.g. Gibson (1975)
* ***Phomopsis*** sp *.. Viegas (1961)
* ***Phyllactinia corylea.*** Spaulding (1961)
* ***Phyllactinia guttata.*** e.g. Browne (1968)
* ***Phyllosticta azedarachis.*** Hepting (1971)
* ***P'hyllosticta ibarrae***. Viegas (1961)
* ***Phyllosticta meliae***. e.g. Hepting (1971)
* ***Phymatotrichopsis omnivora*** (synonym: *Phymatotrichum omnivorum*). e.g. Sinclair et al (1989)
* ***Phytophthora citrophthora.*** e.g. Gibson (1975)
* ***Phytophthora parasitica.*** e.g. Browne (1968)
* ***Pleospora herbarum.*** Viegas (1961)
* ***Pseudocercospora subsessilis*** * (synonym: *Cercospora subsessilis).* e.g. Browne (1968)
* ***Pseudoperonospora portoricensis.*** e.g. Viegas (1961)
* ***Pythium aphanidermatum.*** Viegas (1961)
* ***Pythium ultimum.*** Viegas (1961)
* ***Rosellinia aquila.*** Viegas (1961)
* ***Schizophyllum commune.*** e.g. Browne (1968)
* ***Selenosporium sarcochroum.*** Viegas (1961)
* ***Septobasidium*** sp.. Viegas (1961)
* ***Septoria meliae.*** e.g. Browne (1968)
* ***Septoria*** sp.. Viegas (1961)
* ***Sphaceloma meliae***. e.g. Gibson (1975)
* ***Sphaceloma*** sp.. Viegas (1961)
* ***Strickeria floresiana.*** Viegas (1961)
* ***Teichospora floresiana.*** Viegas (1961)
* ***Trametes pavonia*** (synonym: *Polyporus pavonius*). Stevenson (1975)
* ***Valsa paradisiaca***. Viegas (1961)
* ***Valsaria insitiva***. Viegas (1961)
* ***Valsaria rubricosa.*** Stevenson (1975)
* ***Valsonectria pulchella.*** Viegas (1961)
* ***Xylaria carpophila.*** Viegas (1961)

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* ***Acherontia lachesis*** [Lepidoptera: Sphingidae]. Browne (1968)
* ***Adoxophyes aurata*** * [Lepidoptera: Tortricidae]. Schmutterer (1990)
* ***Africaspis chionaspiformis*** [Homoptera: Coccidae]. Le Pelley (1959)
* ***Aonidiella orientalis*** [Homoptera: Diaspididae]. e.g. Bruner et al (1975)
* ***Apate monachus*** * [Coleoptera: Bostrichidae]. e.g. Browne (1968)
* ***Apate terebrans*** * [Coleoptera: Bostrichidae]. e.g. d'Arujo e Silva et al, (1968)
* ***Aphis*** sp. [Homoptera: Aphididae]. Abai (1984)
* ***Ascotis selenaria*** * [Lepidoptera: Geometridae]. Browne (1968)
* ***Aspidiotus nerii*** [Homoptera: Diaspididae]. d'Arujo e Silva et al (1968)

* ***Asterolecanium pustulans*** [Homoptera: Asterolecaniidae]. Bruner Scaramuzzo and Otero (1975)
* ***Atta sexdens rubropilosa*** [Hymenoptera: Formicidae]. d'Arujo e Silva et al (1968)
* ***Atteva punctella*** [Lepidoptera: Tischeridae]. d'Arujo e Silva et al (1968)
* ***Bostrychopsis jesuita*** [Coleoptera: Bostrichidae]. Browne (1968)
* ***Carineta formosa*** [Homoptera: Cicadidae]. d'Arujo e Silva et al (1968)
* ***Ceroplastes destructor*** [Homoptera: Coccidae]. Browne (1968)
* ***Chionaspis minor*** (synonym: *Pinnaspis minor*) [Homoptera: Diaspididae]. e. g. d'Arujo e Silva et al (1968)
* ***Chrysomphalus aonidum*** * (synonym: *Chrysomphalus ficus*) [Homoptera: Diaspididae]. Schmutterer (1990)
* ***Coccus hesperidum*** [Homoptera: Coccidae]. Schmutterer (1990)
* ***Coptopterus thoracicus*** [Coleoptera: Cerambycidae]. Browne (1968)
* ***Dialeurodes citri*** * [Homoptera: Aleyrodidae]. Browne (1968)
* ***Diploschema rotundicolle*** [Coleoptera: Cerambycidae]. d'Arujo e Silva et al (1968)
* ***Erthesina fullo*** [Heteroptera: Pentatomidae]. Browne (1968)
* ***Hemiberlesia lataniae*** * [Homoptera: Diaspididae]. e.g. Browne (1968)
* ***Hemiberlesia palmae*** * (synonym: *Borchseniaspis palmae*) [Homoptera: Diaspididae]. Schmutterer (1990)
* ***Kalotermes approximatus*** [Isoptera: Kalotermitidae]. Browne (1968)
* ***Leptocneria reducta*** * [Lepidoptera: Lymantriidae]. e.g. Browne (1968)
* ***Orasena*** sp. [Hymenoptera: Eucharitidae]. d'Arujo e Silva et al (1968)
* ***Phryneta spinator*** * [Coleoptera: Cerambycidae]. Browne (1968)
* ***Phyllocnistis selenopa*** [Lepidoptera: Lithocolletidae]. Browne (1968)
* ***Pinnaspis aspidistrae*** [Homoptera: Diaspididae]. d'Arujo e Silva et al (1968)
* ***Pinnaspis strachani*** * [Homoptera: Diaspididae]. Schmutterer (1990)
* ***Platypus navarrodeandradei*** [Coleoptera: Platypodidae]. d'Arujo e Silva et al (1968)
* ***Platypus*** spp. [Coleoptera: Platypodidae]. d'Arujo e Silva et al (1968)
* ***Praxithea derourei*** [Coleoptera: Cerambycidae]. d'Arujo e Silva et al (1968)
* ***Pseudaulacaspis pentagona*** [Homoptera: Diaspididae]. e.g. Schmutterer (1990)
* ***Pseudischnaspis bowreyi*** [Homoptera: Diaspididae]. Bruner, Scaramuzzo and Otero (1975)
* ***Pseudococcus maritimus*** * [Homoptera: Pseudococcidae]. e.g. Browne (1968)
* ***Pseudococcus*** sp. [Homoptera: Pseudococcidae]. d'Arujo e Silva et al (1968)
* ***Psilogramma menephron*** [Lepidoptera: Sphingidae]. Browne (1968)
* ***Ptyelus flavescens*** [Heteroptera: Cercopidae]. Browne (1968)
* ***Pulvinaria ficus*** [Homoptera: Coccidae]. d'Arujo e Silva et al (1968)
* ***Saissetia coffea*** (synonym: *S. hemisphaeria*) [Homoptera: Coccidae]. Bruner et al (1975)
* ***Saissetia somereni*** [Homoptera: Coccidae]. Le Pelley (1959)
* ***Selenaspidus articulatus*** * [Homoptera: Diaspididae]. Bruner et al (1975)
* ***Taylorilygus simonyi*** (synonym: *Lygus simonyi*) [Heteroptera: Miridae]. Le Pelley (1959)
* ***Taylorilygus vosseleri*** (synonym: *Lygus vosseleri*) [Heteroptera: Miridae]. Le Pelley (1959)

* ***Tetranychus*** sp. [Acari: Tetranychidae]. Schmutterer (1990)
* ***Xylosandrus compactus*** [Coleoptera: Scolytidae]. Browne (1968)

MAMMAL

* ***Hystrix indica***. Khan et al (1992)

NEMATODE

* ***Meloidogyne*** spp. Hepting (1971)

PARASITIC PLANTS

* ***Dendrophthoe falcata*** * Browne (1968)
* ***Helixanthera ligustrina*** Browne (1968)
* ***Loranthus corynitis*** (non-preferred; preferred name not known), Browne (1968)
* ***Phoradendron serotinum*** (synonym: *Phoradendron flavescens*). e.g. Hepting (1971)
* ***Phragmanthera incana***. Browne (1968)
* ***Tapinanthus pentagonus***. Browne (1968)
* ***Taxillus umbellifer*** (synonym: *Loranthus umbellifer*). Browne (1968)

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